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ELEMENTS

OF THE

THEORY AND PRACTICE

OF

CHYMISTRY.

Tranſlated from the FRENCH of

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The FIFTH EDITION.

EDINBURGH:
Printed for ALEXANDER DONALDSON; and ſold at his
Shop, No. 48, Eaſt Corner of St. Paul's Church-Yard,
London; and at Edinburgh.
M. DCC. LXXVII.

41134B

THE

AUTHOR's

PREFACE.

AN hundred and fifty years are ſcarce elapſed ſince the clouds of prejudice, which had long overſpread the world, began to clear up, and men were convinced, by cultivating the Sciences, and attending to Nature, that no fanciful hypotheſes would ever lead them to the true cauſes of thoſe various phenomena that inceſſantly and every where meet the obſerver's eye; but that the narrow limits of the human underſtanding confine the courſe of our reſearches to one ſingle path; namely, that of Experiment, or the Uſe of our Senſes. Yet, in this ſhort period, Natural Philoſophy hath riſen to a high pitch of improvement, and may with truth be ſaid to have made much greater advances towards perfection, ſince the experimental method was introduced, than in the many ages before.

This is true with regard to every branch of Natural Philoſophy; but more particularly with regard to Chymiſtry. Though this Science cannot be ſaid to have ever exiſted without experiments, yet it laboured under the ſame diſadvantages with the reſt; becauſe thoſe who ſtudied it made all their experiments with a view to confirm their own Hypotheſes, and in conſequence of principles which had no foundation whatever, but in their wild imaginations.

Hence aroſe that enormous heap, that incongruous jumble of facts, which ſome time ago conſtituted all the knowledge of Chymiſts. Moſt of them, and eſpecially thoſe who aſſumed the pompous title of Alchymiſts, were perſuaded that all the Metals were no other than Nature's rude unfiniſhed eſſays towards making Gold; which, by means of due coction in the bowels of the earth, advanced gradually towards maturity, till at laſt they were perfectly converted into that beautiful and precious Metal.

On this principle, which, if not demonſtrably falſe, is at leaſt utterly deſtitute of proof, and unſupported by a ſingle obſervation, they attempted to finiſh what Nature had begun, by procuring to the imperfect Metals this much deſired coction. To attain it they made an infinite number of experiments and trials; which all conſpired to detect the falſity of their ſyſtem, and to ſatisfy men of ſenſe, that the methods they employed were very far from anſwering the purpoſe.

However, as facts always promote the knowledge of Nature, it happened that thoſe experiments, though quite uſeleſs with regard to the end for which they were originally made, proved the occaſion of ſeveral curious diſcoveries.

Theſe lucky conſequences of their miſtaken labours raiſed the courage of the Chymiſts, or rather Alchymiſts, who looked upon every ſuch inſtance of ſucceſs as a new ſtep towards the Grand Work, and greatly increaſed the fond opinion they entertained of themſelves, and of their Art, which, on that account, they ſet up very high above all other Sciences. Nay, they carried this notion of ſuperiority ſo far, as to hold the reſt of mankind unworthy, or incapable, of riſing to ſuch ſublime knowledge. In conſequence thereof Chymiſtry became an occult and myſterious Science; its expreſſions were all tropes and figures, its phraſes metaphorical, and its axioms ſo many enigmas: in ſhort, an obſcure unintelligible jargon is the juſteſt character of the Alchymiſtic Language.

Thus, by endeavouring to conceal their ſecrets, thoſe gentlemen rendered their Art uſeleſs to mankind,

kind, and brought it into deſerved contempt. But at length the genius of true philoſophy prevailed in Chymiſtry, as well as in the other Sciences. Some great men aroſe, who had generoſity enough to think their knowledge no otherways valuable than as it proved of ſervice to Society. They did their utmoſt to introduce both the knowledge and the practice of many important ſecrets, till then of no uſe; they drew aſide the veil which hid the charms of Chymiſtry; and that Science emerging from the profound obſcurity, in which it had for many ages lain concealed, gained the admiration of the world as ſoon as it appeared in open day. Several ſocieties of ingenious men were formed in the moſt learned countries of Europe, who vied with one another in their labours to execute the noble ſcheme, and aſſiſted each other by mutually communicating their diſcoveries. Chymiſtry made the moſt rapid progreſs, enriching and perfecting the Arts derived from, or depending on it. In a word, it put on a new face, and became truly worthy of the title of Science; founding its principles and its proceſſes on ſolid experiments, and on juſt conſequences deduced from them.

Since that time the Art is become ſo extenſive, by the numerous diſcoveries which Chymiſts have already made, and are daily making, that large volumes are required to contain a complete Treatiſe on the ſubject. In ſhort, Chymiſtry may now, in ſome degree, be compared to Geometry: each of theſe Sciences takes in a moſt ample field of inquiry, which every day enlarges very conſiderably; from each are derived ſeveral Arts, not only uſeful but even neceſſary to Society; each hath its Axioms and its undeniable principles, either demonſtrated from internal evidence, or founded on conſtant experience; ſo that the one, as well as the other, may be reduced to certain fundamental truths, on which all the reſt are built. Theſe fundamental truths connected together, and laid down with order and preciſion, form what we call the Elements of a Science. It is well known that there are many ſuch works relating to Geometry, but it is not ſo with regard to Chymiſtry; there being very few books which treat of this Science in an Elementary manner.

Yet it muſt be owned, that performances of this kind are exceedingly uſeful. Many who have a reliſh for the Sciences, but have not leiſure to read elaborate Works which treat of them minutely, are glad to meet with a book from which, without ſacrificing too much of their time, or neglecting their ordinary buſineſs, they may obtain a taſte or juſt notion of a Science that is not their principal ſtudy. Thoſe who incline to go farther, and learn more, may, by reading an elementary tract, be enabled to underſtand Authors, who, as they commonly write only for proficients in the Art, are obſcure and hardly intelligible to mere beginners. Nay, I preſume to ſay, that an Elementary Treatiſe of Chymiſtry may prove a very uſeful book, even to thoſe who have made ſome progreſs in the Science: for as it contains only the fundamental propoſitions, and indeed is an abſtract of the whole Art, it may help them to recollect the moſt important parts of what they have read in many different works, and fix in their memoirs the moſt eſſential truths, which might elſe be either confounded with others, or entirely forgot. And theſe are the motives which determined me to compoſe the Work which I now offer to the Public.

The general Plan on which I proceed is to ſuppoſe my Reader an abſolute Novice in Chymiſtry; to lead him from the moſt ſimple truths, and ſuch as imply the loweſt degree of knowledge, to ſuch as are more complex, and require a greater acquaintance with Nature. This order, which I have laid down for my rule, hath obliged me to begin with examining the moſt ſimple ſubſtances that we know, and which we conſider as the elements whereof others are compoſed; as, by knowing the properties of theſe elementary parts, we are naturally led to thoſe of their ſeveral combinations; and, on the other hand, in order to know the properties of compound bodies, it is neceſſary we ſhould be firſt acquainted with the properties of their principles. The ſame reaſon induced me, when enquiring into the properties of one ſubſtance, to take no notice of thoſe which relate to any other ſubſtance not treated of before. For example: as I treat of Acids before Metals, I ſay nothing under the head of thoſe Acids concerning their power of diſſolving metals; that I defer till I come to the ſubject of Metals: and thus I avoid ſpeaking prematurely of a ſubſtance with which I ſuppoſe my Reader wholly unacquainted. And this method I was ſo much the more eaſily induced to follow, that I know of no Chymical book written on the ſame Plan.

After diſcourſing of Elements in general, I treat next of ſuch ſubſtances as are immediately compoſed of them, and are, next to them, the moſt ſimple: ſuch are all ſaline ſubſtances. This head comprehends mineral Acids, fixed Alkalis, and their ſeveral combinations; the volatile ſulphureous ſpirit, ſulphur, phoſphorus, and the Neutral ſalts which have an earth or fixed Alkali for their baſis: thoſe which have for their baſis either a volatile Alkali, or ſome metallic ſubſtance, are referred, according to my general Plan, to the heads under which I treat of thoſe ſubſtances.

Metallic ſubſtances are ſcarcely more compounded than the ſaline; which induces me to conſider them next. I begin with thoſe which are the moſt ſimple, or at leaſt ſeem to be ſo; becauſe their principles, being very ſtrongly connected together, are ſeparated with the greateſt difficulty: ſuch are the Metals properly ſo called; namely, Gold, Silver, Copper, Iron, Tin, and Lead. After theſe come the Semi-metals in order; to wit, Regulus of Antimony, Zinc, Biſmuth, and Regulus of Arſenic. Mercury being a doubtful ſubſtance, which ſome Chymiſts rank with the Metals, and others with the Semi-metals, becauſe it actually poſſeſſes certain properties in common with each, I have treated of it in a ſeparate Chapter, which ſtands between the Metals and Semi-metals.

I next proceed to examine the ſeveral ſorts of Oils, whether Vegetable, which are divided into fat, eſſential, and empyreumatic; or Animal, and Mineral Oils.

By examining theſe ſubſtances we obtain ideas of all the principles which enter into the compoſition of Vegetable and Animal bodies; that is, of thoſe ſubſtances that are capable of fermentation: this enables me to treat of fermentation in general; of its three different degrees or kinds, the ſpirituous, acetous, and putrid; and of the products of thoſe fermentations, ardent ſpirits, acids analogous to thoſe of vegetables and animals, and volatile alkalis.

The order in which I treat of all thoſe ſubſtances being different from that in which they are obtained from compound bodies, I give, in a diſtinct Chapter, a general idea of Chymical Decompoſition, with a view to ſhew the order in which they are ſeparated, from the ſeveral bodies in the compoſition whereof they are found. This brings them a ſecond time under review, and give me an opportunity of diſtinguiſhing thoſe which exiſt naturally in compound bodies, from thoſe which are only the reſult of a new combination of ſome of their principles produced by the fire.

The ſucceeding Chapter explains the late Mr Geoffroy's Table of Affinities; which I take to be of great uſe at the end of an Elementary tract like this, as it collects into one point of view the moſt eſſential and fundamental doctrines which are diſperſed through the work.

I conclude with an account of the Conſtruction of ſuch Veſſels and Furnaces as are uſually employed in Chymiſtry.

In this Part I ſay nothing of any manual operations, or the ſeveral ways of performing Chymical proceſſes; reſerving theſe particulars for my Treatiſe of Practical Chymiſtry, to which this muſt be conſidered as an Introduction.

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ELEMENTS

OF THE

THEORY OF CHYMISTRY.

CHAP. I.

Of the PRINCIPLES *of* BODIES.

THE object and principal end of Chymiſtry, is to ſeparate the different ſubſtances that enter into the compoſition of bodies; to examine each of them apart; to diſcover their properties and relations; to decompoſe, if poſſible, thoſe very ſubſtances; to compare them together, and combine them with others; to reunite them again into one body, ſo as to reproduce the original compound with all its properties; or even to produce new compounds that never exiſted among the works of nature, from mixtures of other matters differently combined.

But this Analyſis, or Decompoſition, of bodies is finite; we being unable to carry it beyond a certain limit. In whatever way we attempt to go further, we are always ſtopped by ſubſtances in which we can produce no change, which will not admit of being reſolved into others, and which ſtand as ſo many firm barriers obſtructing our progreſs.

To theſe ſubſtances we may, in my opinion, give the title of Principles or Elements: at leaſt, with regard to us, they are really ſuch. Of this ſort the principal are Earth, Water, Air, and Fire. For though there is ground to believe that theſe are not the primary component parts, or the moſt ſimple elements, of matter; yet, as we know by experience, that our ſenſes cannot poſſibly diſcover the principles of which they are compoſed, it ſeems more reaſonable to fix upon them, and conſider them as ſimple homogeneous bodies, and the principles of the reſt, than to fatigue our minds with vain conjectures about the parts or elements of which they may conſiſt; ſeeing there is no criterion by which we can know whether we have hit upon the truth, or whether the notions we have formed are mere fancies. We ſhall therefore conſider theſe four ſubſtances as the principles or elements of all the various compounds which nature preſents to our inquiries: becauſe, of all thoſe we have as yet diſcovered, they are in fact the moſt ſimple; and becauſe all our decompoſitions, all our experiments on other bodies, plainly prove that they are at laſt reſolvable into theſe primary parts.

Theſe principles do not enter in the ſame proportion into all bodies: there are even ſome mixts in the compoſition of which this or that particular principle is not to be found. Thus Air and Water ſeem to be wholly excluded from the texture of Metals; at leaſt all the experiments that have hitherto been made on them ſeem to confirm this opinion.

The ſubſtances compoſed immediately of theſe *firſt* Elements we ſhall call *ſecondary* Principles; becauſe in reality their ſeveral combinations with each other, the interchangeable coalitions that take place between them, conſtitute the different natures of all other bodies; which, as they reſult from the union both of primary and ſecondary principles, are properly entitled to the name of Compounds or Mixts.

Before we enter upon the examination of Compound Subſtances, it is neceſſary to conſider with ſome attention the moſt Simple ones, or our four firſt principles, in order to diſcover their chief properties.

SECTION I.

Of AIR.

AIR is that Fluid which we conſtantly breathe, and which ſurrounds the whole ſurface of the terreſtrial globe. Being heavy, like all other bodies, it penetrates into all places that are not either abſolutely inacceſſible, or filled with ſome other body heavier than itſelf. Its principal property is to be ſuſceptible of condenſation and rarefaction; ſo that the very ſame quantity of Air may occupy a much greater, or a much ſmaller ſpace, according to the different ſtate it is in. Heat and cold, or, if you will, the preſence and the abſence of the particles of Fire, are the moſt uſual cauſes, and indeed the meaſures, of its condenſation and rarefaction: for if a certain quantity of Air be heated, its bulk enlarges in proportion to the degree of heat applied to it; the conſequence of which is, that the ſame ſpace now contains fewer particles of Air than it did before. Cold again produces juſt the oppoſite effect.

On this property which Air has, of being condenſed and rarefied by heat, its elaſticity or ſpringineſs chiefly depends. For if Air were forced by condenſation into a leſs compaſs than it took up before, and then expoſed to a very conſiderable degree of cold, it would remain quite inactive, without exerting ſuch an effort as it uſually makes againſt the compreſſing body. On the other hand, the elaſticity of heated Air ariſes only from hence, that being rarefied by the action of Fire, it requires much more ſpace than it occupied before.

Air enters into the compoſition of many ſubſtances, eſpecially vegetable and animal bodies: for by analyſing moſt of them ſuch a conſiderable quantity thereof is extricated, that ſome naturaliſts have ſuſpected it to be altogether deſtitute of elaſticity when thus combined with the other principles in the compoſition of bodies. According to them, the efficacy of the elaſtic power of the Air is ſo prodigious, and its force when compreſſed ſo exceſſive, that it is not poſſible the other component parts of bodies ſhould be able to confine ſo much of it, in that ſtate of compreſſion which it muſt needs undergo, if retaining its elaſticity it were pent up among them.

However that be, this elaſtic property of the Air produces the moſt ſingular and important phenomena, obſervable in the reſolution and compoſition of bodies.

SECTION II.

Of WATER.

WATER is a thing ſo well known, that it is almoſt needleſs to attempt giving a general idea of it here. Every one knows that it is a tranſparent, inſipid ſubſtance, and uſually fluid. I ſay it is uſually ſo; for being expoſed to a certain degree of cold it becomes ſolid: ſolidity therefore ſeems to be its moſt natural ſtate.

Water expoſed to the Fire grows hot; but only to a limited degree, beyond which its heat never riſes, be the force of Fire applied to it ever ſo violent: it is known to have acquired this degree of heat by its boiling up with great tumult.

Water cannot be made hotter, becauſe it is volatile, and incapable of enduring the heat, without being evaporated and entirely diſſipated.

If ſuch a violent and ſudden heat be applied to Water, as will not allow it time to exhale gently in vapours, as when, for inſtance, a ſmall quantity thereof is thrown upon a metal in fuſion, it is diſſipated at once with vaſt impetuoſity, producing a moſt terrible and dangerous exploſion. This ſurpriſing effect may be deduced from the inſtantaneous dilatation of the parts of the Water itſelf, or rather of the Air it contains. Moreover, Water enters into the texture of many bodies, both compounds and ſecondary principles; but, like Air, it ſeems to be excluded from the compoſition of all metals and moſt minerals. For although an immenſe quantity of Water exiſts in the bowels of the Earth, moiſtening all its contents, it cannot be thence inferred, that it is one of the principles of minerals. It is only interpoſed between their parts; for they may be entirely diveſted of it, without any ſort of decompoſition: indeed it is not capable of an intimate connection with them.

SECTION III.

Of EARTH.

WE obſerved that the two principles above treated of are volatile; that is, the action of Fire ſeparates them from the bodies they help to compoſe, carrying them quite off, and diſſipating them. That of which we are now to ſpeak, namely Earth, is fixed, and, when it is abſolutely pure, reſiſts the utmoſt force of Fire. So that, whatever remains of a body, after it hath been expoſed to the power of the fierceſt Fire, muſt be conſidered as containing nearly all its earthy principle, and conſiſting chiefly thereof. I qualify my expreſſion thus for two reaſons: the firſt is, becauſe it often happens, that this remainder does not actually contain all the Earth which exiſted originally in the mixt body decompoſed by Fire; ſince it will afterwards appear that Earth, though in its own nature fixed, may be rendered volatile by being intimately united with other ſubſtances which are ſo; and that, in fact, it is common enough for part of the Earth of a body to be thus volatilized by its other principles: the ſecond is, that what remains after the calcination of a body is not generally its earth in perfect purity, but combined with ſome of its other principles, which, though volatile in their own natures, have been fixed by the union contracted between it and them. We ſhall, in the ſequel, produce ſome examples to illuſtrate this theory.

Earth, therefore, properly ſo called, is a fixed principle, which is permanent in the Fire. There is reaſon to think it very difficult, if not impoſſible, to obtain the earthy principle entirely free from every other ſubſtance: for after our utmoſt endeavours to purify them, the Earths we obtain from different compounds are found to have different properties, according to the different bodies from which they are procured; or elſe, if thoſe Earths be pure, we muſt allow them to be eſſentially different, ſeeing they have different properties.

Earth, in general, with regard to its properties, may be diſtributed into *fuſible*, and *unfuſible*; that is, into Earth that is capable of melting or becoming fluid in the Fire, and Earth that conſtantly remains in a ſolid form, never melting in the ſtrongeſt degree of heat to which we can expoſe it.

The former is alſo called *vitrifiable*, and the ſecond *unvitrifiable* Earth; becauſe, when Earth is melted by the force of Fire, it becomes what we call *Glaſs*, which is nothing but the parts of Earth brought into nearer contact, and more cloſely united by the means of fuſion. Perhaps the Earth, which we look upon as incapable of vitrification, might be fuſed if we could apply to it a ſufficient degree of heat. It is at leaſt certain, that ſome Earths, or ſtones, which ſeparately reſiſt the force of Fire, ſo that they cannot be melted, become fuſible when mixed together. Experience convinced Mr. du Hamel that lime-ſtone and ſlate are of this kind. It is however undoubtedly true, that one Earth differs from another in its degree of fuſibility: and this gives ground to believe, that there may be a ſpecies of Earth abſolutely unvitrifiable in its nature, which, being mixed in different proportions with fuſible Earths, renders them difficult to melt.

Whatever may be in this, as there are Earths which we are abſolutely unable to vitrify, that is a ſufficient reaſon for our diviſion of them. Unvitrifiable Earths ſeem to be porous, for they imbibe Water; whence they have alſo got the name of *Abſorbent Earths*.

SECTION IV.

Of FIRE.

THE Matter of the Sun, or of Light, the Phlogiſton, Fire, the Sulphureous Principle, the Inflammable Matter, are all of them names by which the Element of Fire is uſually denoted. But it ſhould ſeem, that an accurate diſtinction hath not yet been made between the different ſtates in which it exiſts; that is, between the phenomena of Fire actually exiſting as a principle in the compoſition of bodies, and thoſe which it exhibits when exiſting ſeparately and in its natural ſtate: nor have proper diſtinct appellations been aſſigned to it in thoſe different circumſtances. In the latter ſtate we may properly give it the names of Fire, Matter of the Sun, of Light, and of Heat; and may conſider it as a ſubſtance compoſed of infinitely ſmall particles, continually agitated by a moſt rapid motion, and, of conſequence, eſſentially fluid.

This ſubſtance, of which the ſun may be called the general reſervoir, ſeems to flow inceſſantly from that ſource, diffuſing itſelf over the world, and through all the bodies we know; but not as a principle, or eſſential part of them, ſince they may be deprived thereof, at leaſt in a great meaſure, without ſuffering any decompoſition. The greateſt change produced on them, by its preſence or its abſence, is the rendering them fluid or ſolid: ſo that all other bodies may be deemed naturally ſolid; Fire alone eſſentially fluid, and the principle of fluidity in others. This being preſuppoſed, Air itſelf might become ſolid, if it could be entirely deprived of the Fire it contains; as bodies of moſt difficult fuſion become fluid, when penetrated by a ſufficient quantity of the particles of Fire.

One of the chief properties of this pure Fire is to penetrate eaſily into all bodies, and to diffuſe itſelf among them with a ſort of uniformity and equality: for if a heated body be contiguous to a cold one, the former communicates to the latter all its exceſs of heat, cooling in exact proportion as the other warms, till both come to have the very ſame degree of heat. Heat, however, is naturally communicable ſooneſt to the upper parts of a body; and conſequently, when a body cools, the under parts become ſooneſt cold. It hath been obſerved, for inſtance, that the lower extremity of a heated body, freely ſuſpended in the air, grows cold ſooner than the upper; and that, when a bar of iron is red-hot at one end, and cold at the other, the cold end is much ſooner heated by placing the bar ſo that the hot end may be undermoſt, than when that end is turned uppermoſt. The levity of the matter of Fire, and the vicinity of the Earth, may poſſibly be the cauſes of this phenomenon.

Another property of Fire is to dilate all bodies into which it penetrates. This hath already been ſhewn with regard to Air and Water; and it produces the ſame effect on Earth.

Fire is the moſt powerful agent we can employ to decompoſe bodies; and the greateſt degree of heat producible by man, is that excited by the rays of the ſun collected in the focus of a large burning-glaſs.

SECTION V.

Of the PHLOGISTON.

FROM what hath been ſaid concerning the nature of Fire, it is evidently impoſſible for us to fix and confine it in any body. Yet the phenomena attending the combuſtion of inflammable bodies ſhew, that they really contain the matter of Fire as a conſtituent principle. By what mechaniſm then is this fluid, which is ſo ſubtle, ſo active, ſo difficult to confine, ſo capable of penetrating into every other ſubſtance in nature; how comes it, I ſay, to be ſo fixed as to make a component part of the moſt ſolid bodies? It is no eaſy matter to give a ſatisfactory anſwer to this queſtion. But, without pretending to gueſs the cauſe of the phenomenon, let us reſt contented with the certainty of the fact, the knowledge of which will undoubtedly procure us conſiderable advantages. Let us therefore examine the properties of Fire thus fixed, and become a principle of bodies. To this ſubſtance, in order to diſtinguiſh it from pure and unfixed Fire, the Chymiſts have aſſigned the peculiar title of the *Phlogiſton*, which indeed is no other than a Greek word for the Inflammable Matter; by which latter name, as well as by that of the Sulphureous Principle, it is alſo ſometimes called. It differs from elementary Fire in the following particulars. 1. When united to a body, it communicates to it neither heat nor light. 2. It produces no change in its ſtate, whether of ſolidity or fluidity; ſo that a ſolid body does not become fluid by the acceſſion of the Phlogiſton, and *vice verſa;* the ſolid bodies to which it is joined being only rendered thereby more apt to be fuſed by the force of the culinary fire. 3. We can convey it from the body with which it is joined into another body, ſo that it ſhall enter into the compoſition thereof, and remain fixed in it.

On this occaſion both theſe bodies, that which is deprived of the Phlogiſton and that which receives it, undergo very conſiderable alterations; and it is this laſt circumſtance, in particular, that obliges us to diſtinguiſh the Phlogiſton from pure Fire, and to conſider it as the element of Fire combined with ſome other ſubſtance, which ſerves it as a baſis for conſtituting a kind of ſecondary principle. For if there were no difference between them, we ſhould be able to introduce and fix pure Fire itſelf, wherever we can introduce and fix the Phlogiſton: yet this is what we can by no means do, as will appear from experiments to be afterwards produced.

Hitherto, Chymiſts have never been able to obtain the Phlogiſton quite pure, and free from every other ſubſtance: for there are but two ways of ſeparating it from a body of which it makes a part; to wit, either by applying ſome other body with which it may unite the moment it quits the former; or elſe by calcining and burning the compound from which you deſire to ſever it. In the former caſe it is evident that we do not get the Phlogiſton by itſelf, becauſe it only paſſes from one combination into another; and in the latter, it is entirely diſſipated in the decompoſition, ſo that no part of it can poſſibly be ſecured.

The inflammability of a body is an infallible ſign that it contains a Phlogiſton; but from a body's not being inflammable, it cannot be inferred that it contains none; for experiments have demonſtrated that certain metals abound with it, which yet are by no means inflammable.

We have now delivered what is moſt neceſſary to be known concerning the principles of bodies in general. They have many other qualities beſides thoſe above-mentioned; but we cannot properly take notice of them here, becauſe they preſuppoſe an acquaintance with ſome other things relating to bodies, of which we have hitherto ſaid nothing; intending to treat of them in the ſequel as occaſion ſhall offer. We ſhall only obſerve in this place, that when animal and vegetable matters are burnt, in ſuch a manner as to hinder them from flaming, ſome part of the Phlogiſton contained in them unites intimately with their moſt fixed earthy parts, and with them forms a compound, that can be conſumed only by making it red-hot in the open air, where it ſparkles and waſtes away, without emitting any flame. This compound is called a *Coal.* We ſhall inquire into the properties of this Coal under the head of Oils: at preſent it ſuffices that we know in general what it is, and that it readily communicates to other bodies the Phlogiſton it contains.

CHAP. II.

A general View of the Relations or Affinities between Bodies.

BEFORE we can reduce compound Bodies to the firſt principles above pointed out, we obtain, by analyſing them, certain ſubſtances which are indeed more ſimple than the bodies they helped to compoſe, yet are themſelves compoſed of our primary principles. They are therefore at one and the ſame time both principles and compounds; for which reaſon we ſhall, as was before ſaid, call them by the name of Secondary Principles. Saline and oily matters chiefly conſtitute this claſs. But before we enter upon an examination of their properties, it is fit we lay before the reader a general view of what Chymiſts underſtand by the Relations or Affinities of Bodies; becauſe it is neceſſary to know theſe, in order to a diſtinct conception of the different combinations we are to treat of.

All the experiments hitherto made concur with daily obſervation to prove, that different bodies, whether principles or compounds, have ſuch a mutual Conformity, Relation, Affinity, or Attraction, if you will call it ſo, as diſpoſes ſome of them to join and unite together, while they are incapable of contracting any union with others. This effect, whatever be its cauſe, will enable us to account for, and connect together, all the phenomena that Chymiſtry produces. The nature of this univerſal affection of matter is diſtinctly laid down in the following propoſitions.

Firſt, If any ſubſtance hath any Affinity or conformity with another, the two will unite together, and form one compound.

Secondly, It may be laid down as a general rule, that all ſimilar ſubſtances have an Affinity with each other, and are conſequently diſpoſed to unite; as water with water, earth with earth, *&c.*

Thirdly, Subſtances that unite together loſe ſome of their ſeparate properties; and the compounds reſulting from their union partake of the properties of thoſe ſubſtances which ſerve as their principles.

Fourthly, The ſimpler any ſubſtances are, the more perceptible and conſiderable are their Affinities: whence it follows, that the leſs bodies are compounded, the more difficult it is to analyſe them; that is, to ſeparate from each other the principles of which they conſiſt.

Fifthly, If a body conſiſt of two ſubſtances, and to this compound be preſented a third ſubſtance, that has no Affinity at all with one of the two primary ſubſtances aforeſaid, but has a greater Affinity with the other than thoſe two ſubſtances have with each other, there will enſue a decompoſition, and a new union; that is, the third ſubſtance will ſeparate the two compounding ſubſtances from each other, coaleſce with that which has an Affinity with it, form therewith a new combination, and diſengage the other, which will then be left at liberty, and ſuch as it was before it had contracted any union.

Sixthly, It happens ſometimes that when a third ſubſtance is preſented to a body conſiſting of two ſubſtances, no decompoſition follows; but the two compounding ſubſtances, without quitting each other, unite with the ſubſtance preſented to them, and form a combination of three principles; and this comes to paſs when that third ſubſtance has an equal, or nearly equal, Affinity with each of the compounding ſubſtances. The ſame thing may alſo happen even when the third ſubſtance hath no Affinity but with one of the compounding ſubſtances only. To produce ſuch an effect, it is ſufficient that one of the two compounding ſubſtances have to the third body a Relation equal, or nearly equal, to that which it has to the other compounding ſubſtance with which it is already combined. Thence it follows, that two ſubſtances, which, when apart from all others, are incapable of contracting any union, may be rendered capable of incorporating together in ſome meaſure, and becoming parts of the ſame compound, by combining with a third ſubſtance with which each of them has an equal Affinity.

Seventhly, A body, which of itſelf cannot decompoſe a compound conſiſting of two ſubſtances, becauſe, as we juſt now ſaid, they have a greater affinity with each other than it has with either of them, becomes nevertheleſs capable of ſeparating the two by uniting with one of them, when it is itſelf combined with another body, having a degree of Affinity with that one, ſufficient to compenſate its own want thereof. In that caſe there are two Affinities, and thence enſues a double decompoſition and a double combination.

Theſe fundamental truths, from which we ſhall deduce an explanation of all the phenomena in Chymiſtry, will be confirmed and illuſtrated by applying them, as we ſhall do, to the ſeveral caſes, of which our deſign in this treatiſe obliges us to give a circumſtantial account.

CHAP. III.

Of Saline Subſtances in general.

IF a particle of water be intimately united with a particle of earth, the reſult will be a new compound, which, according to our third propoſition of Affinities, will partake of the properties of earth and of water; and this combination principally forms what is called a *Saline Subſtance.* Conſequently every Saline Subſtance muſt have an affinity with earth and with water, and be capable of uniting with both or either of them, whether they be ſeparate or mixed together: and accordingly this property characterizes all Salts, or Saline Subſtances, in general.

Water being volatile and Earth fixed, Salts in general are leſs volatile than the former, and leſs fixed than the latter; that is, fire, which cannot volatilize and carry off pure earth, is capable of rarefying and volatilizing a Saline Subſtance; but then this requires a greater degree of heat than is neceſſary for producing the ſame effects on pure water.

There are ſeveral ſorts of Salts, differing from one another, in reſpect either of the quantity, or the quality of the earth in their compoſition; or, laſtly, they differ on account of ſome additional principles, which not being combined with them in ſufficient quantity to hinder their Saline properties from appearing, permit them to retain the name of Salts, though they render them very different from the ſimpleſt Saline Subſtances.

It is eaſy to infer, from what has been ſaid of Salts in general, that ſome of them muſt be more, ſome leſs, fixed or volatile than others, and ſome more, ſome leſs, diſpoſed to unite with water, with earth, or with particular ſorts of earth, according to the nature or the proportion of their principles.

Before we proceed further, it is proper juſt to mention the principle reaſons, which induce us to think that every

Saline Subſtance is actually a combination of earth and water, as we ſuppoſed at our entering on this ſubject. The firſt is, the conformity Salts have with earth and water, or the properties they poſſeſs in common with both. Of theſe properties we ſhall treat fully, as occaſion offers to conſider them, in examining the ſeveral ſorts of Salts. The ſecond is, that all Salts may be actually reſolved into earth and water by ſundry proceſſes; particularly by repeated diſſolution in water, evaporation, deſiccation, and calcination. Indeed the Chymiſts have not yet been able to procure a Saline Subſtance, by combining earth and water together. This favours a ſuſpicion, that, beſides theſe two, there is ſome other principle in the compoſition of ſalts, which eſcapes our reſearches, becauſe we cannot preſerve it when we decompoſe them; but it is ſufficient to our purpoſe, that water and earth are demonſtrably amongſt the real principles of Saline Subſtances, and that no experiment hath ever ſhewn us any other.

SECTION I.

Of ACIDS.

OF all Saline Subſtances, the ſimpleſt is that called an *Acid*, on account of its taſte; which is like that of verjuice, ſorrel, vinegar, and other ſour things, which, for the ſame reaſon, are alſo called Acids. By this peculiar taſte are Acids chiefly known. They have moreover the property of turning all the blue and violet colours of vegetables red, which diſtinguiſhes them from all other ſalts.

The form, under which Acids moſt commonly appear, is that of a tranſparent liquor; though ſolidity is rather their natural ſtate. This is owing to their affinity with water; which is ſo great, that, when they contain but juſt as much of it as is neceſſary to conſtitute them Salts, and conſequently have a ſolid form, they rapidly unite therewith the moment they come into contact with it: and as the air is always loaded with moiſture and aqueous vapours, its contact alone is ſufficient to liquify them; becauſe they unite with its humidity, imbibe it greedily, and by that means become fluid. We therefore ſay, they attract the moiſture of the air. This change of a ſalt from a ſolid to a fluid ſtate, by the ſole contact of the air, is alſo called *Deliquium;* ſo that when a ſalt changes in this manner from a ſolid into a fluid form, it is ſaid to run *per deliquium*. Acids being the ſimpleſt ſpecies of Saline bodies, their affinities with different ſubſtances are ſtronger than thoſe of any other ſort of ſalt with the ſame ſubſtances; which is agreeable to our fourth propoſition concerning Affinities.

Acids in general have a great affinity with earths: that with which they moſt readily unite is the unvitrifiable earth to which we gave the name of abſorbent earth. They ſeem not to act at all upon vitrifiable earths, ſuch as ſand; nor yet upon ſome other kinds of earths, at leaſt while they are in their natural ſtate. Yet the nature of theſe earths may be in ſome meaſure changed, by making them red-hot in the fire, and then quenching them ſuddenly in cold water: for, by repeating this often, they are brought nearer to the nature of abſorbent earths, and rendered capable of uniting with Acids.

When an acid liquor is mixed with an abſorbent earth, for inſtance with chalk, theſe two ſubſtances inſtantly ruſh into union, with ſo much impetuoſity, eſpecially if the acid liquor be as much dephlegmated, or contain as little water, as may be, that a great ebullition is immediately produced, attended with conſiderable hiſſing, heat, and vapours, which riſe the very inſtant of their conjunction.

From the combination of an acid with an abſorbent earth there ariſes a new compound, which ſome Chymiſts have called *Sal Salſum*; becauſe the Acid by uniting with the earth loſes its ſour taſte, and acquires another not unlike that of the common ſea-ſalt uſed in our kitchens; yet varying according to the different ſorts of Acids and earths combined together. The Acid at the ſame time loſes its property of turning vegetable blues and violet colours red.

If we inquire what is become of its propenſity to unite with water, we ſhall find that the earth, which of itſelf is not ſoluble in water, hath, by its union with the Acid, acquired a facility of diſſolving therein; ſo that our *Sal Salſum* is ſoluble in water. But, on the other hand, the Acid hath, by its union with the earth, loſt part of the affinity it had with water; ſo that if a *Sal Salſum* be dried, and freed of all ſuperfluous humidity, it will remain in that dry ſolid form, inſtead of attracting the moiſture of the air, and running *per deliquium*, as the Acid would do if it were pure and unmixed with earth. However, this general rule admits of ſome exceptions; and we ſhall have occaſion in another place to take notice of certain combinations of Acids with earths, which ſtill continue to attract the moiſture of the air, though not ſo ſtrongly as a pure Acid.

Acids have likewiſe a great affinity with the Phlogiſton. When we come to treat of each Acid in particular, we ſhall examine the combinations of each with the Phlogiſton: they differ ſo widely from one another, and many of them are ſo little known, that we cannot at preſent give any general idea of them.

SECTION II.

Of Alkalis.

Alkalis are Saline combinations, in which there is a greater proportion of earth than in Acids. The principal arguments that may be adduced to prove this fact are theſe: Firſt; if they be treated in the manner propoſed above for analyzing Saline Subſtances, we obtain from them a much greater quantity of earth than we do from Acids. Secondly; by combining certain Acids with certain earths we can produce Alkalis; or at leaſt ſuch ſaline compounds as greatly reſemble them. Our third and laſt argument is drawn from the properties of thoſe Alkalis which, when pure and unadulterated with any other principle, have leſs affinity with water than Acids have, and are alſo more fixed, reſiſting the utmoſt force of fire. On this account it is that they have obtained the title of *Fixed*, as well as to diſtinguiſh them from another ſpecies of Alkali, to be conſidered hereafter, which is impure and volatile.

Though fixed Alkalis, when dry, ſuſtain the utmoſt violence of fire without flying off in vapours, it is remarkable that, being boiled with water in an open veſſel, conſiderable quantities of them riſe with the ſteam: an effect which muſt be attributed to the great affinity between theſe two ſubſtances, by means whereof water communicates ſome part of its volatility to the fixed ſalt.

Alkalis freed of their ſuperfluous humidity by calcination attract the moiſture of the air, but not ſo ſtrongly as Acids: ſo that it is eaſier to procure and preſerve them in a ſolid form.

They flow in the fire, and are then capable of uniting with vitrifiable earths, and of forming therewith true glaſs, which, however, will partake of their properties, if they be uſed in ſufficient quantity.

As they melt more readily than vitrifiable earth, they facilitate its fuſion; ſo that a weaker fire will reduce it to glaſs, when a fixed Alkali is joined with it, than will melt it without that addition.

Alkalis are known by their taſte, which is acrid and fiery; and by the properties they poſſeſs of turning vegetable blues and violet colours green; particularly ſyrop of violets.

Their affinity with acids is greater than that of abſorbent earths; and hence it comes to paſs, that if an Alkali be preſented to a combination of an Acid with an abſorbent earth, the earth will be ſeparated from the Acid by the Alkali, and a new union between the Acid and the Alkali will take place. This is both an inſtance and a proof of our fifth propoſition concerning Affinities.

If a pure Alkali be preſented to a pure Acid, they ruſh together with violence, and produce the ſame phenomena as were obſerved in the union of an abſorbent earth with an Acid; but in a greater and more remarkable degree.

Fixed Alkalis may in general be divided into two ſorts: one of theſe hath all the above-recited properties; but the other poſſeſſes ſome that are peculiar to itſelf. We ſhall conſider this latter ſort more particularly under the head of Sea-Salt.

SECTION III.

Of NEUTRAL SALTS.

THE Acid and the Alkali thus uniting mutually rob each other of their characteriſtic properties; ſo that the compound reſulting from their union produces no change in the blue colours of vegetables, and has a taſte which is neither ſour nor acrid, but ſaltiſh. A ſaline combination of this kind is for that reaſon named *Sal Salſum*, *Sal Medium*, or a *Neutral Salt*. Such combinations are alſo called by the plain general name of *Salts*.

It muſt be obſerved that, in order to make theſe Salts perfectly Neutral, it is neceſſary that neither of the two ſaline principles of which they are compounded be predominant over the other; for in that caſe they will have the properties of the prevailing principle. The reaſon is this: neither of theſe ſaline ſubſtances can unite with the other but in a limited proportion, beyond which there can be no further coalition between them. The action by which this perfect union is accompliſhed is termed *Saturation*; and the inſtant when ſuch proportions of the two ſaline ſubſtances are mixed together, that the one is incorporated with as much of the other as it can poſſibly take up, is called the *Point of Saturation.* All this is equally applicable to the combination of an Acid with an abſorbent earth.

The combination is known to be perfect, that is, the Point of Saturation is known to be obtained, when, after repeated affuſions of an Acid in ſmall quantities to an Alkali, or an abſorbent earth, we find thoſe phenomena ceaſe, which in ſuch caſes conſtantly attend the conflict of union, as we ſaid above, namely, ebullition, hiſſing, *&c.* and we may be aſſured the Saturation is complete when the new compound hath neither an acid nor an acrid taſte, nor in the leaſt changes the blue colours of vegetables.

Neutral ſalts have not ſo great an affinity with water as either Acids or Alkalis have; becauſe they are more compounded: for we obſerved before, that the affinities of the moſt compounded bodies are generally weaker than thoſe of the moſt ſimple. In conſequence hereof few Neutral Salts, when dried, attract the moiſture of the air; and thoſe that do, attract it more ſlowly, and in leſs quantity, than either Acids or Alkalis do.

All Neutral Salts are ſoluble in water; but more or leſs readily, and in a greater or ſmaller quantity, according to the nature of their component principles.

Water made boiling hot diſſolves a greater quantity of thoſe ſalts which do not attract the moiſture of the air, than when it is cold; and indeed it muſt be boiling hot to take up as much of them as it is capable of diſſolving: but as for thoſe which run in the air, the difference, if there be any, is imperceptible.

Some Neutral Salts have the property of ſhooting into cryſtals, and others have it not.

The nature of Cryſtallization is this: Water cannot diſſolve, nor keep in ſolution, more than a determinate quantity of any particular Salt: when therefore ſuch a quantity of water is evaporated from the ſolution of a Salt capable of cryſtallization, that the remainder contains juſt as much Salt as it can diſſolve, then by continuing the evaporation the Salt gradually recovers its ſolid form, and concretes into ſeveral little tranſparent maſſes called Cryſtals. Theſe cryſtals have regular figures, all differing from one another according to the ſpecies of ſalt of which they are formed. Different methods of evaporating ſaline ſolutions have different effects on the figure and regularity of the cryſtals; and each particular ſort of ſalt requires a peculiar method of evaporation to make its cryſtals perfectly regular.

A ſolution of ſalt deſigned for cryſtallization is uſually evaporated by means of fire to a pellicle; that is, till the Salt begin to concrete; which is perceived by a kind of thin dark ſkin that gathers on the ſurface of the liquor, and is formed of the cryſtallized particles of Salt. When this pellicle appears the ſolution is ſuffered to cool, and the cryſtals form therein faſter or ſlower, according to the ſort of ſalt in hand. If the evaporation be carried on briſkly to perfect dryneſs, no cryſtals will be formed, and only an irregular maſs of ſalt will be obtained.

The reaſons why no cryſtals appear when the evaporation is haſtily performed, and carried on to dryneſs, are, firſt, that the particles of ſalt, being always in motion while the ſolution is hot, have not time to exert their mutual affinities, and to unite together as cryſtallization requires: Secondly, that a certain quantity of water enters into the very compoſition of cryſtals; which is therefore abſolutely neceſſary to their formation, and in a greater or ſmaller proportion according to the nature of the Salt[*].

If theſe cryſtallized ſalts be expoſed to the fire, they firſt part with that moiſture which is not neceſſary to a ſaline concretion, and which they retained only by means of their cryſtallization: afterwards they begin to flow, but with different degrees of fuſibility.

It muſt be obſerved, that certain ſalts melt as ſoon as they are expoſed to the fire; namely, thoſe which retain a great deal of water in cryſtallizing. But this fluor which they ſo readily acquire muſt be carefully diſtinguiſhed from actual fuſion: for it is owing only to their ſuperfluous humidity, which heat renders capable of diſſolving and liquifying them; ſo that when it is evaporated the Salt ceaſes to be fluid, and requires a much greater degree of fire to bring it into real fuſion.

The Neutral Salts that do not cryſtallize may, indeed, be dried by evaporating the water which keeps them fluid; but by becoming ſolid they acquire no regular form; they again attract the moiſture of the air, and are thereby melted into a liquor. Theſe may be called *Liqueſcent Salts*.

Moſt of the Neutral Salts, that conſiſt of an Acid joined with a fixed Alkali, or with an abſorbent earth, are themſelves fixed and reſiſt the force of fire; yet ſeveral of them, if they be diſſolved in water, and the ſolution boiled and evaporated, fly off along with the ſteams.

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[*] Thoſe who have the curioſity to ſee a more particular account of the Cryſtallization of Neutral Salts, may read Mr. *Rouelle*'s excellent Memoir on that ſubject, among thoſe of the Academy of Sciences for 1744.

CHAP. IV.

Of the ſeveral Sorts of Saline Subſtances.

SECTION I.

Of the UNIVERSAL ACID.

THE Univerſal Acid is ſo called, becauſe it is in fact the Acid which is moſt univerſally diffuſed through all nature, in waters, in the atmoſphere, and in the bowels of the earth. But it is ſeldom pure; being almoſt always combined with ſome other ſubſtance. That from which we obtain it with moſt eaſe, and in the greateſt quantity, is Vitriol, a mineral which we ſhall conſider afterwards: and this is the reaſon why it is called the *Vitriolic Acid;* the name by which it is beſt known.

When the Vitriolic Acid contains but little phlegm, yet enough to give it a fluid form, it is called *Oil of Vitriol,* on account of a certain unctuoſity belonging to it. In truth this name is very improperly beſtowed on it; for we ſhall afterwards ſee that, bating this unctuouſneſs, it has none of the properties of oils. But this is not the only impropriety in names that we ſhall have occaſion to cenſure.

If the Vitriolic Acid contain much water, it is then called *Spirit of Vitriol.* When it does not contain enough to render it fluid, and ſo is in a ſolid form, it is named the *Icy Oil of Vitriol.*

When Oil of Vitriol highly concentrated is mixed with water, they ruſh into union with ſuch impetuoſity, that, the moment they touch each other, there ariſes a hiſſing noiſe, like that of red-hot iron plunged in cold water, together with a very conſiderable degree of heat, proportioned to the degree to which the Acid was concentrated.

If, inſtead of mixing this concentrated Acid with water, you only leave it expoſed to the air for ſome time, it attracts the moiſture thereof, and imbibes it moſt greedily. Both its bulk and its weight are increaſed by this acceſſion; and if it be under an icy form, that is, if it be concreted, the phlegm thus acquired will ſoon reſolve it into a fluid.

The addition of water renders the Vitriolic Acid, and indeed all other Acids, weaker in one ſenſe; which is, that when they are very aqueous they leave on the tongue a much fainter taſte of acidity, and are leſs active in the ſolution of ſome particular bodies: but that occaſions no change in the ſtrength of their affinities, but in ſome caſes rather enables them to diſſolve ſeveral ſubſtances, which, when well dephlegmated, they are not capable of attacking.

The Vitriolic Acid combined to the point of ſaturation with a particular abſorbent earth, the nature of which is not yet well known, forms a Neutral Salt that cryſtallizes. This Salt is called *Alum*, and the figure of its cryſtals is that of an octahedron, or ſolid of eight ſides. Theſe octahedra are triangular pyramids, the angles of which are ſo cut off that four of the ſurfaces are hexagons, and the other four triangles.

There are ſeveral ſorts of Alum, which differ according to the earths combined with the Vitriolic Acid. Alum diſſolves eaſily in water, and in cryſtallization retains a conſiderable quantity of it; which is the reaſon that being expoſed to the fire it readily melts, ſwelling and puffing up as its ſuperfluous moiſture exhales. When that is quite evaporated, the remainder is called *Burnt Alum*, and is very difficult to fuſe. The Acid of the Alum is partly diſſipated by this calcination. Its taſte is ſaltiſh, with a degree of roughneſs and aſtringency.

The Vitriolic Acid combined with certain earths forms a kind of Neutral Salt called *Selenites*, which cryſtallizes in different forms according to the nature of its earth. There are numberleſs ſprings of water infected with diſſolved Selenites; but when this Salt is once cryſtallized, it is exceeding difficult to diſſolve it in water a ſecond time. For that purpoſe a very great quantity of water is neceſſary, and moreover it muſt boil; for as it cools moſt of the diſſolved Selenites takes a ſolid form, and falls in a powder to the bottom of the veſſel.

If an Alkali be preſented to the Selenites, or to Alum, theſe Salts, according to the principles we have laid down, will be thereby decompoſed; that is, the Acid will quit the earths, and join the Alkali, with which it hath a greater affinity. And from this conjunction of the Vitriolic Acid with a fixed Alkali there reſults another ſort of Neutral Salt, which is called *Arcanum duplicatum*, *Sal de duobus*, and *Vitriolat-*

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ed Tartar, becauſe one of the fixed Alkalis moſt in uſe is called Salt of Tartar.

Vitriolated Tartar is almoſt as hard to diſſolve in water as the Selenites. It ſhoots into eight-ſided cryſtals, having the apices of the pyramids pretty obtuſe. Its taſte is ſaltiſh, inclining to bitter; and it decrepitates on burning coals. It requires a very great degree of fire to make it flow.

The Vitriolic Acid is capable of uniting with the Phlogiſton, or rather it has a greater affinity with it than with any other body: whence it follows, that all compounds, of which it makes a part, may be decompoſed by means of the Phlogiſton.

From the conjunction of the Vitriolic Acid with the Phlogiſton ariſes a compound called *Mineral Sulphur*, becauſe it is found perfectly formed in the bowels of the earth. It is alſo called *Sulphur vivum*, or ſimply *Sulphur*.

Sulphur is abſolutely inſoluble in water, and incapable of contracting any ſort of union with it. It melts with a very moderate degree of heat, and ſublimes in fine light downy tufts called *Flowers of Sulphur*. By being thus ſublimed, it ſuffers no decompoſition, let the operation be repeated ever ſo often; ſo that Sublimed Sulphur, or Flower of Sulphur, hath exactly the ſame properties as Sulphur that has never been ſublimed.

If Sulphur be expoſed to a briſk heat in the open air, it takes fire, burns, and is wholly conſumed. This deflagration of Sulphur is the only means we have of decompoſing it, in order to obtain its Acid in purity. The Phlogiſton is deſtroyed by the flame, and the Acid exhales in vapours: theſe vapours collected have all the properties of the Vitriolic Acid, and differ from it only as they ſtill retain ſome portion of the Phlogiſton; which, however, ſoon quits them of its own accord, if the free acceſs of the common air be not precluded.

The portion of Phlogiſton retained by the Acid of Sulphur is much more conſiderable when that mineral is burnt gradually and ſlowly: in that caſe the vapours which riſe from it have ſuch a penetrating odour, that they inſtantaneouſly ſuffocate any perſon who draws in a certain quantity of them with his breath. Theſe vapours conſtitute what is called the *Volatile Sprit of Sulphur*. There is reaſon to think this portion of Phlogiſton which the Acid retains is combined therewith in a manner different from that in which theſe two are united in the Sulphur itſelf; for, as has juſt been obſerved, nothing but actual burning is capable of ſeparating the Vitriolic Acid and the Phlogiſton, which by their union form Sulphur; whereas in the Volatile Spirit of Sulphur they ſeparate ſpontaneouſly when expoſed to the open air; that is, the Phlogiſton flies off and leaves the Acid, which then becomes in every reſpect ſimilar to the Vitriolic Acid.

That the Volatile Spirit of Sulphur is a compound, as we have aſſerted it to be, appears evidently from hence, that whenever the Vitriolic Acid touches any ſubſtance containing the Phlogiſton, provided that Phlogiſton be diſengaged or opened to a certain degree, a Volatile Spirit of Sulphur is infallibly and immediately generated. This Spirit hath all the properties of Acids, but conſiderably weakened, and of courſe leſs perceptible. It unites with abſorbent earths or fixed Alkalis; and with them forms Neutral Salts; but when combined therewith it may be ſeparated from them by the Vitriolic Acid, and indeed by any of the mineral Acids, becauſe its affinities are weaker. Sulphur hath the property of uniting with abſorbent earths, but not near ſo intimately as with fixed Alkalis.

If equal parts of Sulphur and an Alkali be melted together, they incorporate with each other; and from their conjunction proceeds a compound of a moſt unpleaſant ſmell, much like that of rotten eggs, and of a red colour nearly reſembling that of an animal liver, which has occaſioned it to bear the name of *Hepar Sulphuris*, or *Liver of Sulphur.*

In this compoſition the fixed Alkali communicates to the Sulphur the property of diſſolving in water: and hence it comes that Liver of Sulphur may be made as well when the Alkali is diſſolved by water into a fluid, as when it is fuſed by the action of fire.

Sulphur has leſs affinity than any Acid with the fixed Alkalis: and therefore Liver of Sulphur may be decompounded by any Acid whatever; which will unite with the fixed Alkali, form therewith a Neutral Salt, and ſeparate the Sulphur.

If Liver of Sulphur be diſſolved in water, and an Acid poured thereon, the liquor, which was tranſparent before, inſtantly turns to an opaque white; becauſe the Sulphur, being forced to quit its union with the Alkali, loſes at the ſame time the property of diſſolving in water, and appears again in its own opaque form. The liquor thus made white by the Sulphur is called *Milk of Sulphur.*

If this liquor be ſuffered to ſtand ſtill for ſome time, the particles of Sulphur, now moſt minutely divided, gradually approach each other, unite, and fall inſenſibly to the bottom of the veſſel; and then the liquor recovers its tranſparency. The Sulphur thus depoſited on the bottom of the veſſel is called the *Magiſtery* or *Precipitate of Sulphur*. The names of Magiſtery and Precipitate are alſo given to all ſubſtances whatever, that are ſeparated from another by this method; which is the reaſon that we uſe the expreſſion of precipitating one ſubſtance by another, to ſignify the ſeparating one of them by means of the other.

SECTION II.

Of the NITROUS ACID.

IT is not certainly known what conſtitutes the difference between the Nitrous Acid and the Vitriolic Acid, with regard to the conſtituent principles of each. The moſt probable opinion is, that the Nitrous Acid is no other than the Vitriolic Acid combined with a certain quantity of Phlogiſton by the means of putrefaction. If it be ſo, the Phlogiſton muſt be united with the Univerſal Acid in another manner than it is in ſulphur, and in its volatile ſpirit: for the Nitrous Acid differs from them both in its properties. What gives ground for this opinion is, that the Nitrous Acid is never found but in earths and ſtones which have been impregnated with matters ſubject to putrefaction, and which therefore muſt contain the Phlogiſton. For it is neceſſary juſt to obſerve here, though it be not yet proper to enter particularly into the ſubject, that all ſubſtances ſuſceptible of putrefaction really contain the Phlogiſton.

The Nitrous Acid combined with certain abſorbent earths, ſuch as chalk, marle, boles, forms Neutral Salts which do not cryſtallize; and which, after being dried, run in the air *per deliquium*.

All thoſe Neutral Salts which conſiſt of the Nitrous Acid joined to an earth, may be decompoſed by a fixed Alkali, with which the Acid unites, and deſerts the earth; and from this union of the Nitrous Acid with a fixed Alkali reſults a new Neutral Salt which is called *Nitre*, or *Salt-peter*. This latter name ſignifies the *Salt of Stone;* and, in fact, Nitre is extracted from the ſtones and plaſter, in which it forms, by boiling them in water ſaturated with a fixed Alkali.

Nitre ſhoots in long cryſtals adhering ſideways to each other;

ther; it has a ſaltiſh taſte, which produces a ſenſation of cold on the tongue.

This Salt eaſily diſſolves in water; which, when boiling hot, takes up ſtill a greater quantity thereof.

It flows with a pretty moderate degree of heat, and continues fixed therein; but being urged by a briſk fire, and in the open air, it lets go ſome part of its Acid, and indeed flies off itſelf in part.

The moſt remarkable property of Nitre, and that which characterizes it, is its fulmination or exploſion; the nature of which is as follows:

When Nitre touches any ſubſtance containing a Phlogiſton, and actually ignited, that is, actually on fire, it burſts out into a flame, burns, and is decompounded with much noiſe.

In this deflagration the Acid is diſſipated, and totally ſeparated from the Alkali, which now remains by itſelf.

Indeed the Acid, at leaſt the greateſt part of it, is by this means quite deſtroyed. The Alkali which is left when Nitre is decompounded by deflagration, is called in general *Fixed Nitre*, and, more particularly, Nitre fixed by ſuch and ſuch a ſubſtance as was uſed in the operation. But if Nitre be deflagrated with an inflammable ſubſtance containing the vitriolic Acid, as ſulphur, for inſtance, the fixed Salt produced by the deflagration is not a pure Alkali, but retains a good deal of the vitriolic Acid, and, by combining therewith, hath now formed a neutral Salt.

Hitherto Chymiſts have been at a loſs for the reaſon why Nitre flames, and is decompounded in the manner abovementioned, when it comes in contact with a Phlogiſton properly circumſtanced. For my part, I conjecture it to be for the ſame reaſon that vitriolated tartar is alſo decompounded by the addition of a Phlogiſton; *viz.* the Nitrous Acid, having a greater affinity with the Phlogiſton than with the fixed Alkali, naturally quits the latter to join with the former, and ſo produces a kind of ſulphur, differing probably from the common ſulphur, formed by the vitriolic Acid, in that it is combuſtible to ſuch a degree, as to take fire and be conſumed in the very moment of its production; ſo that it is impoſſible to prevent its being thus deſtroyed, and conſequently impoſſible to ſave it. In ſupport of this opinion let it be conſidered, that the concurrence of the Phlogiſton is abſolutely neceſſary to produce this deflagration, and that the matter of pure fire is altogether incapable of effecting it: for though Nitre be expoſed to the moſt violent degree of fire, even that in the focus of the moſt powerful burning-glaſs, it will not flame; nor will that effect ever happen till the Nitre be brought into contact with a Phlogiſton properly ſo called, that is, the matter of fire exiſting as a principle of ſome body; and it is moreover neceſſary that this Phlogiſton be actually on fire, and agitated with the igneous motion, or elſe that the Nitre itſelf be red hot, and ſo penetrated with fire as to kindle any inflammable matter that touches it.

This experiment, among others, helps to ſhew the diſtinction that ought to be made between pure elementary fire, and fire become a principle of bodies, to which we have given the name of Phlogiſton.

Before we leave this ſubject, we ſhall obſerve, that Nitre deflagrates only with ſuch ſubſtances as contain the Phlogiſton in its ſimpleſt and pureſt form; ſuch as charcoal, ſulphur, and the metalline ſubſtances; and that, though it will not deflagrate without the addition of ſome combuſtible matter, it is nevertheleſs the only known body that will burn, and make other combuſtibles burn with it, in cloſe veſſels, without the admiſſion of freſh air.

The Nitrous Acid hath not ſo great an affinity with earths and Alkalis as the vitriolic Acid hath with the ſame ſubſtances; whence it follows that the vitriolic Acid decompoſes all neutral ſalts ariſing from a combination of the Nitrous Acid with an earth or an Alkali. The vitriolic Acids expells the Nitrous Acid, unites with the ſubſtance which ſerved it for a baſis, and therewith forms a neutral ſalt, which is an Alum, a Selenites, or a vitriolated Tartar, according to the nature of that baſis.

The Nitrous Acid, when thus ſeparated from its baſis by the vitriolic Acid, is named *Spirit of Nitre*, or *Aqua Fortis*. If it be dephlegmated, or contain but little ſuperfluous water, it exhales in reddiſh vapours; theſe vapours, being condenſed and collected, form a liquor of a browniſh yellow, that inceſſantly emits vapours of the ſame colour, and of a pungent diſagreeable ſmell. Theſe characters have procured it the names of *Smoaking Spirit of Nitre*, and *Yellow Aqua Fortis*. This property in the Nitrous Acid, of exhaling in vapours, ſhews it to be leſs fixed than the vitriolic Acid; for the latter, though ever ſo thoroughly dephlegmated, never yields any vapours, nor has it any ſmell.

SECTION III.

Of the ACID OF SEA-SALT.

THE Acid of Sea-ſalt is ſo called becauſe it is in fact obtained from ſuch Sea-ſalt as is uſed in our kitchens. It is not certainly known in what this Acid differs from the vitriolic and the nitrous, with regard to its conſtituent parts. Several of the ableſt Chymiſts, ſuch as Becher and Stahl, are of opinion that the Marine Acid is no other than the Univerſal Acid united to a particular principle which they call a Mercurial Earth. Concerning this earth we ſhall have occaſion to ſay more, when we come to treat of metallic ſubſtances: but in the mean time it muſt be owned, that the truth of this opinion is ſo far from being proved by a ſufficient number of experiments, that the very exiſtence of ſuch a mercurial earth is not yet well eſtabliſhed; and therefore, that we may not exeeed the bounds of our knowledge, we ſhall content ourſelves with delivering here the properties which characterize the Acid in queſtion, and by which it is diſtinguiſhed from the two others conſidered above.

When it is combined with abſorbent earths, ſuch as lime and chalk, it forms a neutral ſalt that does not cryſtallize, and, when dried, attracts the moiſture of the air. If the abſorbent earth be not fully ſaturated with the Marine Acid, the ſalt thereby formed has the properties of a fixed Alkali: and this is what made us ſay, when we were on the ſubject of thoſe ſalts, that they might be imitated by combining an earth with an Acid. The Marine Acid, like the reſt, hath not ſo great an affinity with earths as with fixed Alkalis.

When it is combined with the latter, it forms a neutral ſalt which ſhoots into cubical cryſtals. This ſalt is inclined to grow moiſt in the air, and is conſequently one of thoſe which water diſſolves in equal quantities, at leaſt as to ſenſe, whether it be boiling hot or quite cold.

The affinity of this Acid with Alkalis and abſorbent Earths is not ſo great as that of the vitriolic and nitrous Acids with the ſame ſubſtances: whence it follows, that, when combined therewith, it may be ſeparated from them by either of thoſe Acids.

The Acid of Sea-ſalt, thus diſengaged from the ſubſtance which ſerved it for a baſis, is called *Spirit of Salt*. When it contains but little phlegm it is of a lemon colour, and continually emits many white, very denſe, and very elaſtic vapours; on which account it is named the *Smoaking Spirit of Salt*. Its ſmell is not diſagreeable, nor much unlike that of ſaffron; but extremely quick and ſuffocating when it ſmokes.

The Acid of Sea-ſalt, like the other two, ſeems to have a greater affinity with the Phlogiſton, than with fixed Alkalis. We are led to this opinion by a very curious operation, which gives ground to think that Sea-ſalt may be decompoſed by the proper application of a ſubſtance containing the Phlogiſton.

From the Marine Acid combined with a Phlogiſton reſults a kind of Sulphur, differing from the common ſort in many reſpects; but particularly in this property, that it takes fire of itſelf upon being expoſed to the open air. This combination is called *Engliſh Phoſphorus*, *Phoſphorus of Urine*, becauſe it is generally prepared from urine; or, only *Phoſphorus*.

This combination of the Marine Acid with a Phlogiſton is not eaſily effected; becauſe it requires a difficult operation in appropriated veſſels. For theſe reaſons it does not always ſucceed; and Phoſphorus is ſo ſcarce and dear, that hitherto Chymiſts have not been able to make on it the experiments neceſſary to diſcover all its properties. If Phoſphorus be ſuffered to burn away in the air, a ſmall quantity of an acid liquor may be obtained from it, which ſeems to be ſpirit of ſalt, but either altered, or combined with ſome adventitious matter; for it has ſeveral properties that are not to be found in the pure Marine Acid; ſuch as, leaving a fixed fuſible ſubſtance behind it when expoſed to a ſtrong fire, and being eaſily combined with the Phlogiſton ſo as to reproduce a Phoſphorus.

Phoſphorus reſembles ſulphur in ſeveral of its properties: it is ſoluble in oils; it melts with a gentle heat; it is very combuſtible; it burns without producing ſoot; and its flame is vivid and bluiſh.

From what has been ſaid of the union of the Acid of Sea-ſalt with a fixed Alkali, and of the neutral ſalt reſulting therefrom, it may be concluded that this neutral ſalt is no other than the common kitchen-ſalt. But it muſt be obſerved, that the fixed Alkali, which is the natural baſis of the common ſalt obtained from ſea-water, is of a ſort ſomewhat differing from fixed Alkalis in general, and hath certain properties peculiar to itſelf. For,

1. The baſis of Sea-ſalt differs from other fixed Alkalis in this, that it cryſtallizes like a neutral ſalt.

2. It does not grow moiſt in the air; on the contrary, when expoſed to the air, it loſes part of the water that united with it in cryſtallization, by which means its cryſtals loſe their tranſparency, become, as it were, mealy, and fall into a fine flour.

3. When combined with the vitriolic Acid to the point of ſaturation, it forms a neutral ſalt differing from vitriolated tartar, firſt, in the figure of its cryſtals, which are oblong ſix-ſided ſolids; ſecondly, in its quantity of water, which in cryſtallization unites therewith in a much greater proportion than with vitriolated tartar; whence it follows, that this ſalt diſſolves in water more readily than vitriolated tartar; thirdly, in that it flows with a very moderate degree of heat, whereas vitriolated tartar requires a very fierce one.

If the Acid of Sea-ſalt be ſeparated from its baſis by means of the vitriolic Acid, it is eaſy to ſee that, when the operation is finiſhed, the ſalt we have been ſpeaking of muſt be the reſult. A famous Chymiſt, named Glauber, was the firſt who extracted the Spirit of Salt in this manner, examined the neutral ſalt reſulting from his proceſs, and, finding it to have ſome ſingular properties, called it his *Sal mirabile*, or wonderful Salt: on this account it is ſtill called Glauber's *Sal mirabile*, or plainly *Glauber's Salt.*

4. When the baſis of Sea-ſalt is combined with the nitrous Acid to the point of ſaturation, there reſults a neutral ſalt, or a ſort of nitre, differing from the common nitre, firſt, in that it attracts the moiſture of the air pretty ſtrongly; and this makes it difficult to cryſtallize; ſecondly, in the figure of its cryſtals, which are parallelopipeds; and this has procured it the name of *Quadrangular Nitre.*

Common ſalt, or the neutral ſalt formed by combining the Marine Acid with this particular ſort of fixed Alkali, has a taſte well known to every body. The figure of its cryſtals is exactly cubical. It grows moiſt in the air, and, when expoſed to the fire, it burſts, before it melts, into many little fragments, with a crackling noiſe; which is called the *Decrepitation* of Sea-ſalt.

That neutral ſalt mentioned above, which is formed by combining the Marine Acid with a common fixed Alkali, and called *Sal febrifugum Sylvii*, hath alſo this property.

India furniſhes us with a ſaline ſubſtance, known by the name of *Borax*, which flows very eaſily, and then takes the form of glaſs. It is of great uſe in facilitating the fuſion of metallic ſubſtances. It poſſeſſes ſome of the properties of fixed Alkalis, which has induced certain Chymiſts to repreſent it, through miſtake, as a pure fixed Alkali.

By mixing borax with the vitriolic Acid, Mr. Homberg obtained from it a ſalt, which ſublimes in a certain degree of heat, whenever ſuch a mixture is made. This ſalt has very ſingular properties; but its nature is not yet thoroughly underſtood. It diſſolves in water with great difficulty; it is not volatile, though it riſes by ſublimation from the borax. According to Mr. Rouelle's obſervation, it riſes then only by means of the water which carries it up: for, when once made, it abides the fierceſt fire, flows and vitrifies juſt as borax does: provided care be taken to free it previouſly from moiſture by drying it properly. Mr. Homberg called it *Sedative Salt*, on account of its medical effects. The ſedative ſalt hath the appearance, and ſome of the properties, of a neutral ſalt; for it ſhoots into cryſtals, and does not change the colour of violets; but it acts the part of an Acid with regard to Alkalis, uniting with them to the point of ſaturation, and thereby forming a true neutral ſalt. It alſo acts, like the Acid of vitriol on all neutral ſalts; that is, it diſcharges the Acid of ſuch as have not the vitriolic Acid in their compoſition.

Since Mr. Homberg's time it hath been diſcovered, that a ſedative ſalt may be made either with the nitrous or with the marine Acid; and that ſublimation is not neceſſary to extract it from the borax, but that it may be obtained by cryſtallization only. For this latter diſcovery we are indebted to Mr. Geoffry, as we are to Mr. Lemery for the former.

Since that time M. Baron d'Henouville, an able Chymiſt, hath ſhewn that a ſedative ſalt may be obtained by the means of vegetable Acids; and hath lately demonſtrated, in ſome excellent papers publiſhed in the collection of Memoirs written by the correſpondents of the Academy of Sciences, that the ſedative ſalt exiſts actually and perfectly in the borax, and that it is not produced by mixing Acids with that ſaline ſubſtance, as it ſeems all the Chymiſts before him imagined. This he proves convincingly from his analyſis of borax, (which thereby appears to be nothing elſe but the ſedative ſalt united with that fixed Alkali which is the baſis of Sea-ſalt) and from his regenerating the ſame borax by uniting together that Alkali and the ſedative ſalt: a proof the moſt complete that can poſſibly be produced in natural philoſophy, and equivalent to demonſtration itſelf.

In order to finiſh what remains to be ſaid upon the ſeveral ſorts of ſaline ſubſtances, we ſhould now ſpeak of the Acids obtained from vegetables and animals, and alſo of the volatile Alkalis: but, ſeeing theſe ſaline ſubſtances differ from thoſe of which we have already treated, only as they are variouſly altered by the unions they have contracted with certain principles of vegetables and animals, of which nothing has been yet ſaid, it is proper to defer being particular concerning them, till we have explained thoſe principles.

CHAP. V.

Of LIME.

ANY ſubſtance whatever, that has been roaſted a conſiderable time in a ſtrong fire without melting, is commonly called a *Calx.* Stones and metals are the principal ſubjects that have the property of being converted into *Calces.* We ſhall treat of Metalline *Calces* in a ſubſequent chapter, and in this confine ourſelves to the *Calx* of *Stone*, known by the name of *Lime.*

In treating of earths in general we obſerved that they may be divided into two principal kinds; one of which actually and properly flows when expoſed to the action of fire, and turns to glaſs; whence it is called a *fuſible* or *vitrifiable* earth; the other reſiſts the utmoſt force of fire, and is therefore ſaid to be an *unfuſible* or *unvitrifiable* earth. The latter is alſo not uncommonly called *calcinable* earth; though ſundry ſorts of unfuſible earths are incapable of acquiring by the action of fire all the qualities of *calcined* earth, or *Lime* properly ſo called: ſuch earths are particularly diſtinguiſhed by the denomination of *refractory* earths.

As the different ſorts of ſtones are nothing more than compounds of different earths, they have the ſame properties with the earths of which they are compoſed, and may, like them, be divided into fuſible or vitrifiable, and unfuſible or calcinable. The fuſible ſtones are generally denoted by the name of *Flints;* the calcinable ſtones, again, are the ſeveral ſorts of marbles, cretaceous ſtones, thoſe commonly called free-ſtones, *&c.* ſome of which, as they make the beſt Lime, are, by way of eminence, called *Lime-ſtones.* Sea-ſhells, alſo, and ſtones that abound with foſſile ſhells, are capable of being burnt to Lime.

All theſe ſubſtances, being expoſed, for a longer or ſhorter time, as the nature of each requires, to the violent action of fire, are ſaid to be *calcined*. By calcination they loſe a conſiderable part of their weight, acquire a white colour, and become friable though ever ſo ſolid before; as, for inſtance, the very hardeſt marbles. Theſe ſubſtances, when thus calcined, take the name of *Quick Lime*.

Water penetrates Quick Lime, and ruſhes into it with vaſt activity. If a lump of newly calcined Lime be thrown into water, it inſtantly excites almoſt as great a noiſe, ebullition, and ſmoke, as would be produced by a piece of red-hot iron; with ſuch a degree of heat too, that, if the Lime be in due proportion to the water, it will ſet fire to combuſtible bodies; as hath unfortunately happened to veſſels laden with Quick Lime, on their ſpringing a ſmall leak.

As ſoon as Quick Lime is put into water, it ſwells, and falls aſunder into an infinite number of minute particles: in a word, it is in a manner diſſolved by the water, which forms therewith a ſort of white paſte called *Slacked Lime*.

If the quantity of water be conſiderable enough for the Lime to form with it a white liquor, this liquor is called *Lac Calcis;* which, being left ſome time to ſettle, grows clear and tranſparent, the Lime which was ſuſpended therein, and occaſioned its opacity, ſubſiding to the bottom of the veſſel. Then there forms on the ſurface of the liquor a cryſtalline pellicle, ſomewhat opaque and dark-coloured, which being ſkimmed off is reproduced from time to time. This matter is called *Cremor Calcis*.

Slacked Lime gradually grows dry, and takes the form of a ſolid body, but full of cracks and deſtitute of firmneſs. The event is different when you mix it up, while yet a paſte, with a certain quantity of uncalcined ſtony matter, ſuch as ſand, for example: then it takes the name of *Mortar*, and gradually acquires, as it grows drier and older, a hardneſs equal to that of the beſt ſtones. This is a very ſingular property of Lime, nor is it eaſy to account for it: but it is a beneficial one; for every body knows the uſe of Mortar in building.

Quick Lime attracts the moiſture of the air, in the ſame manner as concentrated acids, and dry fixed alkalis; but not in ſuch quantities as to render it fluid: it only falls into extremely ſmall particles, takes the form of a fine powder, and the title of *Lime ſlacked in the air*.

Lime once ſlacked, however dry it may afterwards appear, always retains a large portion of the water it had imbibed;

which cannot be ſeparated from it again but by means of a violent calcination. Being ſo recalcined it returns to be Quick Lime, recovering all its properties.

Beſides this great affinity of Quick Lime with water, which diſcovers a ſaline character, it has ſeveral other ſaline properties, to be afterwards examined, much reſembling thoſe of fixed alkalis. In Chymiſtry it acts very nearly as thoſe ſalts do, and may be conſidered as holding the middle rank between a pure abſorbent earth and a fixed alkali: and this hath induced many Chymiſts to think that Lime contains a true ſalt, to which all the properties it poſſeſſes in common with ſalts may be attributed.

But as the chymical examination of this ſubject hath long been neglected, the exiſtence of a ſaline ſubſtance in Lime hath been long doubtful. Mr. du Fay, author of ſome excellent chymical experiments, was one of the firſt who obtained a ſalt from Lime, by lixiviating it with a great deal of water, which he afterwards evaporated. But the quantity of ſalt he obtained by that means was very ſmall; nor was it of an alkaline nature, as one would think it ſhould have been, conſidering the properties of Lime. Mr. du Fay did not carry his experiments on this ſubject any further, probably for want of time; nor did he determine of what nature the ſalt was.

Mr. Malouin had the curioſity to examine this ſalt of Lime, and ſoon found that it was nothing elſe but what was above called *Cremor Calcis*. He found, moreover, that, by mixing a fixed alkali with lime-water, a vitriolated tartar was formed; that, by mixing therewith an alkali like the baſis of ſea-ſalt, a Glauber's ſalt was produced; and, laſtly, by combining lime with a ſubſtance abounding in phlogiſton, he obtained a true ſulphur. Theſe very ingenious experiments prove to a demonſtration, that the vitriolic acid conſtitutes the ſalt of Lime: for, as hath been ſhewn, no other acid is capable of forming ſuch combinations. On the other hand, Mr. Malouin, having forced the vitriolic acid of this ſalt to combine with a phlogiſton, found its baſis to be earthy, and analogous to that of the ſelenites: whence he concluded, that the ſalt of Lime is a true neutral ſalt, of the ſame kind as the ſelenites. Mr. Malouin tells us he found ſeveral other ſalts in Lime. But as none of them was a fixed alkali, and as all the ſaline properties of Lime have an affinity with thoſe of that kind of ſalt, there is great reaſon to think that all thoſe ſalts are foreign to Lime, and that their union with it is merely accidental.

I myſelf have made ſeveral experiments in order to get ſome inſight into the ſaline nature of Lime, and ſhall here produce the reſult with all poſſible conciſeneſs. I took ſeveral ſtones of different kinds, ſome of which produced by calcination a very ſtrong Lime, and others but a very weak one. Theſe I impregnated with different ſaline ſubſtances, acids, alkalis, and neutrals, and then expoſed them all to the ſame degree of fire, which was a pretty ſtrong one, and long enough continued to have made very good Lime of ſtones the moſt difficult to calcine. The conſequence was, that, in the firſt place, thoſe ſtones which naturally made but a weak Lime were not, by this proceſs, converted into a ſtronger Lime; and, moreover, that none of theſe ſtones, even ſuch as would naturally have produced the moſt active Lime, had acquired the properties of Lime These experiments I varied many ways, employing different proportions of ſaline matters, and almoſt every poſſible degree of fire, and conſtantly obſerved, after calcination, that all thoſe ſtones were ſo much the farther from the nature of Lime, as they had been combined with larger doſes of ſalts. Among thoſe which were impregnated with the greateſt proportion of ſalts, and had ſuffered the greateſt violence of fire, I obſerved ſome that had begun to flow, and were in a manner vitrified. Now, as the ſame ſubject cannot be, at one and the ſame time, in the ſtate of glaſs and of Lime too; as a body cannot approach to one of theſe ſtates but in proportion as it recedes from the other; and as ſalts in general diſpoſe thoſe bodies to fuſion and vitrification which are in themſelves the moſt averſe to either, I concluded from my experiments, that the ſaline ſubſtances I uſed, had, by acting as fluxes upon the ſtones, prevented their calcination; that conſequently we may ſuſpect there is no ſaline matter in the compoſition of Lime, as Lime; and that Lime does not owe its ſaline and alkaline properties to any ſalt; or at leaſt that, if it does owe thoſe properties to a ſalt, ſuch ſalt muſt be naturally and originally combined with the matter of the ſtone in ſo juſt a proportion, that it is impoſſible to increaſe the quantity thereof without prejudicing the Lime, and depriving it in ſome meaſure of its virtue. This theory agrees perfectly with the illuſtrious Stahl's opinion; for he thinks, as we obſerved in diſcourſing of ſalts in general, that every ſaline ſubſtance is but an earth combined in a certain manner with water. This notion he applies to Lime, and ſays, that fire only ſubtilizes and attenuates the earthy matter, and thereby renders it capable of uniting with water in ſuch a manner, that the reſult of their combination ſhall be a ſubſtance having ſaline properties; and that Lime accordingly never acquires theſe properties till it be combined with water.

I have dwelt longer on the Salt of Lime than I ſhall on any other particular; becauſe the ſubject, though in itſelf of great importance, has hitherto been but little attended to, and becauſe the experiments here recited are entirely new.

Lime unites with all acids, and in conjunction with them exhibits various phenomena.

The vitriolic acid poured upon Lime diſſolves it with effervеſcence and heat. From this mixture there exhales a great quantity of vapours, in ſmell and colour perfectly like thoſe of ſea-ſalt; from which, however, they are found to be very different when collected into a liquor. From this combination of the vitriolic acid with Lime ariſes a neutral ſalt, which ſhoots into cryſtals, and is of the ſame kind with the ſelenetic ſalt obtained from Lime by Mr. Malouin.

The nitrous acid poured upon Lime diſſolves it in like manner with effervеſcence and heat: but the ſolution is tranſparent, and therein differs from the former, which is opaque. From this mixture there ariſes a neutral ſalt, which does not cryſtallize, and has withal the very ſingular property of being volatile, and riſing wholly by diſtillation in a liquid form. This phenomenon is ſo much the more remarkable, as Lime, the baſis of this ſalt, is one of the moſt fixed bodies known in Chymiſtry.

With the acid of ſea-ſalt Lime forms alſo a ſingular ſort of ſalt, which greedily imbibes the moiſture of the air. We ſhall have occaſion to take further notice of it in another place.

Theſe experiments made on Lime with acids are likewiſe quite new. We are indebted for them to Mr. Du Hamel of the Academy of Sciences, whoſe admirable Memoirs on ſeveral ſubjects ſhew his extenſive knowledge in all parts of Natural Philoſophy.

Lime applied to fixed alkalis adds conſiderably to their cauſtic quality, and makes them more penetrating and active. An alkaline lixivium in which Lime hath been boiled, being evaporated to dryneſs, forms a very cauſtic ſubſtance, which flows in the fire much more eaſily, attracts and retains moiſture much more ſtrongly, than fixed alkalis that have not been ſo treated. An alkali thus acuated by Lime is called the *Cauſtic Stone*, or *Potential Cautery*; becauſe it is employed by ſurgeons to produce eſchars on the ſkin and cauterize it.

CHAP. VI.

Of Metallic Subſtances in general.

METALLIC Subſtances are heavy, glittering, opaque, fuſible bodies. They conſiſt chiefly of a vitrifiable earth united with the phlogiſton.

Several Chymiſts inſiſt on a third principle in theſe bodies, and have given it the name of *Mercurial Earth;* which, according to Becher and Stahl, is the very ſame that being combined with the vitriolic acid forms and characterizes the acid of ſea-ſalt. The exiſtence of this principle hath not yet been demonſtrated by any deciſive experiment; but we ſhall ſhew that there are pretty ſtrong reaſons for admitting it.

We ſhall begin with mentioning the experiments which prove Metallic Subſtances to conſiſt of a vitrifiable earth united with the phlogiſton. The firſt is this: if they be calcined in ſuch a manner as to have no communication with any inflammable matter, they will be ſpoiled of all their properties, and reduced to an earth or calx, that has neither the ſplendour nor the ductility of a metal, and in a ſtrong fire turns to an actual glaſs, inſtead of flowing like a metal.

The ſecond is, that the calx or the glaſs reſulting from a metal thus decompoſed, recovers all its metalline properties by being fuſed in immediate contact with an inflammable ſubſtance, capable of reſtoring the phlogiſton of which calcination had deprived it.

On this occaſion we muſt obſerve, that Chymiſts have not yet been able, by adding the phlogiſton, to give the properties of metals to all ſorts of vitrifiable earths indiſcriminately; but to ſuch only as originally made a part of ſome metallic body. For example, a compound cannot be made with the phlogiſton and ſand that ſhall have the leaſt reſemblance of a metal: and this is what ſeems to point out the reality of a third principle, as neceſſary to form the metalline combination. This principle may probably remain united with the vitrifiable earth of a metallic ſubſtance, when reduced to a glaſs; whence it follows, that ſuch vitrified metals require only the addition of a phlogiſton to enable them to appear again in their priſtine form.

It may be inferred from another experiment, that the calx and the glaſs of a metal are not its pure vitrifiable earth, properly ſo called: for by repeated or long-continued calcinations, ſuch a calx or glaſs may be rendered incapable of ever reſuming the metalline form, in whatever manner the phlogiſton be afterwards applied to it; ſo that by this means it is brought into the condition of a pure vitrifiable earth, abſolutely free from any mixture. Thoſe Chymiſts who patronize the Mercurial earth, produce many other proofs of the exiſtence of that principle in Metallic Subſtances; but they would be miſplaced in an elementary treatiſe like this.

When by adding the phlogiſton to a metallic glaſs we reſtore it to the form of a metal, we are ſaid to *reduce*, *reſuſcitate*, or *revivify* that metal.

Metallic Subſtances are of different kinds, and are divided into *Metals* and *Semi-metals*.

Thoſe are called Metals which, beſides their metalline ſplendour and appearance, are alſo malleable; that is, have the property of ſtretching under the hammer, and by that means of being wrought into different forms without breaking.

Thoſe which have only the metalline ſplendour and appearance, without malleability, are called Semi-metals.

Metals are alſo further ſubdivided into two ſorts; *viz.* *Perfect* and *Imperfect* Metals.

The Perfect Metals are thoſe which ſuffer no damage or change whatever by the moſt violent and moſt laſting action of fire.

The Imperfect Metals are thoſe which by the force of fire may be deprived of their phlogiſton, and conſequently of their metalline form.

When but a moderate degree of fire is employed to deprive a Metal of its phlogiſton, the metal is ſaid to be *calcined;* and then it appears in the form of a powdered earth, which is called a *Calx:* and this metalline calx being expoſed to a more violent degree of fire melts and turns to glaſs.

Metallic Subſtances have an affinity with acids: but not equally with all; that is, every Metallic Subſtance is not capable of uniting and joining with every acid.

When an acid unites with a Metallic Subſtance there commonly ariſes an ebullition, attended with a kind of hiſſing noiſe and fuming exhalations. By degrees, as the union becomes more perfect, the particles of the metal combining with the acid become inviſible: this is termed *Diſſolution*; and when a metalline maſs thus appears in an acid, the metal is ſaid to be *diſſolved* by that acid. It is proper to obſerve, that acids act upon Metalline Subſtances, in one reſpect, juſt as they do upon alkalis and abſorbent earths: for an acid cannot take up above ſuch a certain proportion thereof as is ſufficient to ſaturate it, to deſtroy ſeveral of its properties, and weaken others. For example, when an acid is combined with a metal to the point of ſaturation, it loſes its taſte, does not turn the blue colour of a vegetable red, and its affinity with water is conſiderably impaired. On the other hand, Metalline Subſtances, which when pure are incapable of uniting with water, by being joined with an acid acquire the property of diſſolving in water. Theſe combinations of Metalline Subſtances with acids form different ſorts of neutral ſalts; ſome of which have the property of ſhooting into cryſtals, while others have it not: moſt of them, when thoroughly dried, attract the moiſture of the air.

The affinity which Metalline Subſtances have with acids is leſs than that which abſorbent earths and fixed alkalis have with the ſame acids; ſo that all metalline ſalts may be decompounded by one of theſe ſubſtances, which will unite with the acid, and precipitate the metal.

Metalline Subſtances thus ſeparated from an acid ſolvent are called *Magiſteries* and *Precipitates* of metals. None of theſe precipitates, except thoſe of the perfect metals, retain the metalline form: moſt of their phlogiſton hath been deſtroyed by the ſolution and precipitation, and muſt be reſtored before they can recover their properties. In ſhort, they are nearly in the ſame ſtate with Metalline Subſtances deprived of their phlogiſton by calcination; and accordingly ſuch a precipitate is called a *Calx*.

A metalline calx prepared in this manner loſes a greater or a leſs portion of its phlogiſton, the more or leſs effectually and thoroughly the Metalline Subſtance, of which it made a part, was diſſolved by the acid.

Metallic Subſtances have affinities with each other which differ according to their different kinds: but this is not univerſal; for ſome of them are incapable of any ſort of union with ſome others.

It muſt be obſerved, that Metallic Subſtances will not unite, except they be both in a ſimilar ſtate; that is, both in a Metalline form, or both in the form of a Glaſs; for a Metalline Subſtance retaining its phlogiſton cannot contract an union with any metallic glaſs, even its own.

CHAP. VII.

Of METALS.

THERE are ſix Metals, of which two are Perfect and four Imperfect. The perfect Metals are Gold and Silver; the others are Copper, Tin, Lead, and Iron. Some Chymiſts admit a ſeventh Metal, to wit, Quick-ſilver: but as it is not malleable, it has been generally conſidered as a metallic body of a particular kind. We ſhall ſoon have occaſion to examine it more minutely.

The ancient Chymiſts, or rather the Alchymiſts, who fancied a certain relation or analogy between Metals and the Heavenly Bodies, beſtowed on the ſeven Metals, reckoning Quick-ſilver one of them, the names of the ſeven Planets of the Ancients, according to the affinity which they imagined they obſerved between thoſe ſeveral bodies. Thus Gold was called *Sol*, Silver *Luna*, Copper *Venus*, Tin *Jupiter*, Lead *Saturn*, Iron *Mars*, and Quick-ſilver *Mercury*. Though theſe names were aſſigned for reaſons merely chimerical, yet they ſtill keep their ground; ſo that it is not uncommon to find the Metals called by the names, and denoted by the characters, of the Planets, in the writings even of the beſt Chymiſts. Metals are the heavieſt bodies known in nature.

SECTION I.

Of GOLD.

GOLD is the heavieſt of all Metals. The arts of wire-drawing and gold-beating ſhew its wonderful ductility. The greateſt violence of fire is not able to produce any alteration in it. Indeed Mr. Homberg, a famous Chymiſt, pretended that he had made this metal fume, and even vitrified it, by expoſing it to the focus of one of the beſt burning-glaſſes, known by the name of the Lens of the *Palais Royal:* but, there are very good reaſons for calling in queſtion the experiments he made on this occaſion, or rather for thinking that he was quite miſtaken. For,

1. No man hath ſince been able to vitrify Gold, though ſeveral good Experimenters have aſſiduouſly tried to effect it, by expoſing it to the focus of the ſame lens, and of other burning-glaſſes ſtill ſtronger.

2. It hath been obſerved, that though Gold, when expoſed to the focus of thoſe glaſſes, did indeed emit ſome vapours and decreaſe in weight; yet, thoſe vapours being carefully collected on a piece of paper, proved to be true Gold, in no degree vitrified, and which conſequently had ſuffered no change but that of being carried away by the violence of the heat, its nature not being in the leaſt altered.

3. The ſmall portion of vitrified matter, which was formed on the arm that ſupported the Gold in Mr. Homberg's experiment, may have come either from the arm itſelf, or rather from ſome heterogeneous particles contained in the Gold; for it is almoſt impoſſible to have it perfectly pure.

4. Neither Mr. Homberg, nor any that have repeated his experiment, ever reduced this pretended glaſs of Gold by reſtoring its Phlogiſton, as is done with other metallic glaſſes.

5. To render the experiment deciſive, the whole maſs of Gold employed ought to have been vitrified; which was not the caſe.

Nevertheleſs, I do not pretend that this metal is in its own nature abſolutely indeſtructible, and unvitrifiable: but there is reaſon to think that no body hath hitherto found the means of producing thoſe effects on it, probably for want of a ſufficient degree of fire; at leaſt the point is very doubtful.

Gold cannot be diſſolved by any pure acid: but if the acid of nitre be mixed with the acid of ſea-ſalt, there reſults a compound acid liquor, with which it has ſo great an affinity that it is capable of being perfectly diſſolved thereby. The Chymiſts have called this ſolvent *Aqua Regis*, on account of its being the only acid that can diſſolve Gold, which they conſider as the King of Metals. The ſolution of gold is of a beautiful orange colour.

If Gold diſſolved in *aqua regis* be precipitated by an alkali or an abſorbent earth, the precipitate gently dried, and then expoſed to a certain degree of heat, is inſtantly diſperſed into the air, with a moſt violent exploſion and noiſe: Gold thus precipitated is therefore called *Aurum Fulminans*. But if the precipitated Gold be carefully waſhed in plenty of water, ſo as to clear it of all the adhering ſaline particles, it will not fulminate, but may be melted in a crucible without any additament, and will then appear in its uſual form. The acid of vitriol being poured on *aurum fulminans* likewiſe deprives it of its fulminating quality.

Gold does not begin to flow till it be red-hot like a live coal. Though it be the moſt malleable and moſt ductile of all metals, it has the ſingular property of loſing its ductility more eaſily than any of them: even the fumes of charcoal are ſufficient to deprive it thereof, if they come in contact with it while it is in fuſion.

The malleability of this metal, and indeed of all the reſt, is alſo conſiderably diminiſhed by expoſing it ſuddenly to cold when it is red-hot; for example, by quenching it in water, or even barely expoſing it to the cold air.

The way to reſtore ductility to gold, when loſt by its coming in contact with the vapour of coals, and in general to any metal rendered leſs malleable by being ſuddenly cooled, is to heat it again, to keep it red hot a conſiderable time, and then to let it cool very ſlowly and gradually; this operation frequently repeated will by degrees much increaſe the malleability of a metal.

Pure ſulphur hath no effect on Gold; but being combined with an alkali into a *hepar ſulphuris*, it unites therewith very readily. Nay, ſo intimate is their union, that the Gold, by means thereof, becomes ſoluble in water; and this new compound of Gold and liver of ſulphur, being diſſolved in water, will paſs through the pores of brown paper without ſuffering any decompoſition; which does not happen, at leaſt in ſuch a manifeſt degree, to other metallic ſubſtances diſſolved by liver of ſulphur.

Aurum fulminans, mixed and melted with flower of ſulphur, loſes its fulminating quality: which ariſes from hence, that on this occaſion the ſulphur burns, and its acid, which is the ſame with the vitriolic, being thereby ſet at liberty becomes capable of acting upon the Gold as a vitriolic acid would; which, as was ſaid above, deprives the Gold of its fulminating quality.

SECTION II.

Of SILVER.

NEXT to Gold, Silver is the moſt perfect metal. Like Gold it reſiſts the utmoſt violence of fire, even that in the focus of a burning-glaſs. However, it holds only the ſecond place among metals; becauſe it is lighter than Gold by almoſt

moſt one half; is alſo ſomewhat leſs ductile; and, laſtly, becauſe it is acted upon by a greater number of ſolvents.

Yet Silver hath one advantage over gold, namely that of being a little harder; which makes it alſo more ſonorous.

This metal, like Gold, begins to flow when it is ſo thoroughly penetrated by the fire as to appear ignited like a live coal.

While this metal is in fuſion, the immediate contact of the vapour of burning coals deprives it almoſt entirely of its malleability, in the ſame manner as we obſerved happens to Gold: but both theſe metals eaſily recover that property by being melted with nitre.

The nitrous acid is the true ſolvent of Silver, and being ſomewhat dephlegmated will very readily and eaſily take up a quantity of Silver equal in weight to itſelf.

Silver thus combined with the nitrous acid forms a metallic ſalt which ſhoots into cryſtals, called by the name of *Lunar Cryſtals*, or *Cryſtals of Silver*.

Theſe cryſtals are moſt violently cauſtic: applied to the ſkin they quickly affect it much as a live coal would; they produce a blackiſh eſchar, corroding and entirely deſtroying the parts they touch. Surgeons uſe them to eat away the proud fungous fleſh of ulcers. As Silver united with the nitrous acid hath the property of blackening all animal ſubſtances, a ſolution of this metallic ſalt is employed to dye hair, or other animal matters, of a beautiful and durable black.

Theſe cryſtals flow with a very moderate heat, and even before they grow red Being thus melted they form a blackiſh maſs; and in this form they are uſed by Surgeons, under the title of *Lapis Infernalis*, *Infernal Stone*, or *Lunar Cauſtic*.

Silver is alſo diſſolved by the vitriolic acid: but then the acid muſt be concentrated, and in quantity double the weight of the Silver; nor will the ſolution ſucceed without a conſiderable degree of heat.

Spirit of ſalt and *aqua regis*, as well as the other acids, are incapable of diſſolving this metal; at leaſt in the ordinary way.

Though Silver be not ſoluble in the acid of ſea-ſalt, nor eaſily in the acid of vitriol, as hath juſt been obſerved, it doth not follow that it hath but a weak affinity with the latter, and none at all with the former: on the contrary, it appears from experiment that it hath with theſe two acids a much greater affinity than with the acid of nitre: which is ſingular enough, conſidering the facility with which this laſt acid diſſolves it.

The experiment which proves the fact, is this. To a ſolution of Silver in the nitrous acid, add the acid either of vitriol or of ſea-ſalt, and the Silver will inſtantly quit its nitrous ſolvent to join with the ſuperadded acid.

Silver thus united with the vitriolic or the marine acid is leſs ſoluble in water than when combined with the nitrous acid; and for this reaſon it is, that when either of theſe two acids is added to a ſolution of Silver, the liquor immediately becomes white, and a precipitate is formed, which is no other than the Silver united with the precipitating acid. If the precipitation be effected by the vitriolic acid, the precipitate will diſappear upon adding a ſufficient quantity of water, becauſe there will then be water enough to diſſolve it. But the caſe is not the ſame when the precipitation is made by the marine acid; for Silver combined therewith is ſcarce ſoluble in water.

This Precipitate of Silver, procured by means of the marine acid, is very eaſily fuſed, and when fuſed changes to a ſubſtance in ſome meaſure tranſparent and flexible, which hath occaſioned it to be called by the name of *Luna Cornea.* If it be propoſed to decompound this *luna cornea*, that is, to ſeparate the marine acid from the Silver with which it is united, the *luna cornea* muſt be melted along with fatty and abſorbent matters, with which the acid will unite, and leave the metal exceeding pure.

It muſt be obſerved, that if, inſtead of the marine acid, ſea-ſalt in ſubſtance be added to a ſolution of Silver in the nitrous acid, a Precipitate is alſo produced, which by fuſion appears to be a true *luna cornea.* The reaſon is, that the ſea-ſalt is decompoſed by the nitrous acid, which ſeizes its baſis, as having a greater affinity therewith than its own acid hath; and this acid being conſequently diſengaged and ſet at liberty unites with the Silver, which, as has been ſhewn, has a greater affinity with it than with the nitrous acid. This is an inſtance of decompoſition effected by means of one of thoſe double affinities mentioned by us in our ſeventh propoſition concerning Affinities.

From what hath been already ſaid it is clear, that all theſe combinations of Silver with acids may be decompounded by abſorbent earths and by fixed alkalis; it being a general law with regard to all metallic ſubſtances. We ſhall not therefore repeat this obſervation when we come to treat of the other metals; unleſs ſome particular occaſion require it.

With regard to Silver I muſt take notice that, when ſeparated by theſe means from the acids in which it was diſſolved, it requires nothing but ſimple fuſion to reſtore it to its uſual form; becauſe it does not, any more than Gold, loſe its Phlogiſton by thoſe ſolutions and precipitations.

Silver unites with ſulphur in fuſion. If this metal be only made red-hot in a crucible, and ſulphur be then added, it immediately flows; the ſulphur acting as a flux to it. Silver thus united with ſulphur forms a maſs that may be cut, is half malleable, and hath nearly the colour and conſiſtence of Lead. If this ſulphurated Silver be kept a long time in fuſion, and in a great degree of heat, the ſulphur flies off and leaves the Silver pure. But if the ſulphur be evaporated by a violent heat, it carries off with it part of the Silver.

Silver unites and mixes perfectly with Gold in fuſion. The two metals thus mixed form a compound with properties partaking of both.

Metallurgiſts have hitherto ſought in vain for a perfectly good and eaſy method of ſeparating theſe two metals by the *dry way* only: (this term is uſed to ſignify all operations performed by fuſion): but they are conveniently enough parted by the *moiſt way*, that is, by acid ſolvents. This method is founded on the above-mentioned properties of Gold and Silver with reſpect to acids. It hath been ſhewn that *aqua regis* only will diſſolve Gold; that Silver, on the contrary, is not ſoluble by *aqua regis*, and that its proper ſolvent is the acid of nitre; conſequently, when Gold and Silver are mixed together, if the compound maſs be put into *aqua fortis*, this acid will take up all the Silver, without diſſolving a particle of the Gold, which will therefore remain pure; and by this means the deſired ſeparation is effected. This method, which is commonly made uſe of by Goldſmiths, and in Mints, is called the *Parting Aſſay*.

It is plain, that if *aqua regis* were employed inſtead of *aqua fortis*, the ſeparation would be equally effected; and that the only difference between this proceſs and the former would conſiſt in this, that now the Gold would be diſſolved, and the Silver remain pure. But the operation by *aqua fortis* is preferable; becauſe *aqua regis* does take up a little Silver, whereas *aqua fortis* hath not the leaſt effect on Gold.

It muſt be obſerved, that, when Gold and Silver are mixed together in equal parts, they cannot be parted by the means of *aqua fortis*. To enable the *aqua fortis* to act duly on the Silver, this metal muſt be, at leaſt, in a triple proportion to the Gold. If it be in a leſs proportion, you muſt either employ *aqua regis* to make the ſeparation, or, if you prefer the uſe of *aqua fortis*, melt the metalline maſs, and add as much Silver as is neceſſary to make up the proportion above-mentioned: and hence this Proceſs is called *Quartation*.

This effect, which is pretty ſingular, probably ariſes from hence, that when the Gold exceeds or even equals the Silver in quantity, the parts of both being intimately united, the former are capable of coating over the latter, and covering them ſo as to defend them from the action of the *aqua fortis*; which is not the caſe when there is thrice as much Silver as Gold.

There is one thing more to be taken notice of with regard to this proceſs; which is, that perfectly pure *aqua fortis* is rarely to be met with, for two reaſons; firſt, it is difficult in making it wholly to prevent the riſing of the medium employed to diſengage the nitrous acid; that is, a little of the vitriolic acid will mix with the vapours of the *aqua fortis*: ſecondly, unleſs the ſaltpetre be very well purified it will always hold ſome ſmall portion of ſea-ſalt, the acid of which, we know, is very readily ſet looſe by the vitriolic acid, and conſequently riſes together with the vapours of the *aqua fortis*. It is eaſy to ſee that *aqua fortis* mixed either with the one or the other is not proper for the Parting Proceſs; becauſe, as has juſt been ſaid, the vitriolic and the marine acid equally precipitate Silver diſſolved in the nitrous acid; by which means, when they are united with that acid, they weaken its action upon the Silver, and hinder the diſſolution. Add, that *aqua fortis* adulterated with a mixture of ſpirit of ſalt becomes an *aqua regis*, and conſequently is rendered capable of diſſolving Gold, in proportion as its action upon Silver is diminiſhed.

In order to remedy this inconvenience, and free *aqua fortis* from the vitriolic or marine acid with which it is tainted, Silver muſt be diſſolved therein: by degrees as the metal diſſolves, thoſe heterogeneous acids lay hold of it, and precipitate with it in the form of a white powder, as we obſerved before. This precipitate being wholly fallen, the liquor grows clear; after which, if it be found capable of diſſolving more ſilver, without turning milky, it may be depended on as a perfectly pure *aqua fortis*. Then filtre it, diſſolve more Silver in it, as long as it will take up any, and you will have a ſolution of Silver in a very pure *aqua fortis*. By means of this ſolution may other *aqua fortis* be

purified:

purified: for pour a few drops thereof into a very impure *aqua fortis*, and immediately the vitriolic or marine acid, with which that *aqua fortis* is contaminated, will join the Silver and fall therewith to the bottom. When the ſolution of Silver, prepared as above, does not in the leaſt affect the tranſparency of the *aqua fortis*, it is then very pure, and fit for the purpoſes of Quartation.

This operation of purifying *aqua fortis* by a ſolution of Silver is called the *Precipitation* of *Aqua Fortis*, and *aqua fortis* thus purified is called *Precipitated Aqua Fortis*.

When Silver is diſſolved in *aqua fortis* it may be ſeparated therefrom, as hath been ſhewn, by abſorbent earths and fixed alkalis.

We ſhall ſee by and by that there are other means of effecting this: but whatever way it be ſeparated from its ſolvent it recovers its metalline form, as Gold does, by being ſimply fuſed without any additament.

SECTION III.

Of COPPER.

OF all the imperfect metals Copper comes the neareſt to Gold and Silver. Its natural colour is a deep-red yellow. It reſiſts a very violent degree of fire for a conſiderable time; but loſing its phlogiſton at laſt, it changes its metalline form for that of a calx, or a pure reddiſh earth. This calx is hardly, if at all, reducible to glaſs, without the addition of ſomething to promote its fuſion; all that the fierceſt heat can do being only to render it ſoft. Copper, even while it retains its metalline form, and is very pure, requires a conſiderable degree of fire to melt it, and does not begin to flow till long after it is red-hot. When in fuſion, it communicates a greeniſh colour to the flame of the coals.

This metal is inferior to Silver in point of gravity; nor is its ductility ſo great, though it be pretty conſiderable: but, on the other hand, it exceeds that metal in hardneſs. It unites readily with Gold and Silver; nor does it greatly leſſen their beauty when added to them in a ſmall quantity: nay, it even procures them ſome advantages; ſuch as making them harder, and leſs ſubject to loſe their ductility, of which thoſe metals are often liable to be deprived, by the mixture of the ſmalleſt heterogeneous particle. This may probably ariſe from hence, that the ductility of Copper has the peculiarity of reſiſting moſt of thoſe cauſes which rob the perfect metals of theirs.

The property, which other metalline ſubſtances have in common with Copper, of loſing the phlogiſton by calcining and then vitrifying, furniſhes us with a method of ſeparating them from Gold and Silver, when they are combined therewith. Nothing more is required than to expoſe the maſs compounded of the perfect metals and other metalline ſubſtances to a degree of heat ſufficient to calcine whatever is not either Gold or Silver. It is evident, that, by this means, theſe two metals will be obtained as pure as is poſſible; for, as hath already been ſaid, no metalline calx or glaſs is capable of uniting with metals poſſeſſed of their phlogiſton. On this principle is formed the whole buſineſs of refining Gold and Silver.

When the perfect metals have no other alloy but Copper, as this metal is not to be calcined or vitrified without great difficulty, which is increaſed by its union with the unvitrifiable metals, it is eaſy to ſee that it is almoſt impoſſible to ſeparate them without adding ſomething to facilitate the vitrification of the Copper. Such metals as have the property of turning eaſily to glaſs are very fit for this purpoſe; and it is neceſſary to add a certain quantity thereof, when Gold or Silver is to be purified from the alloy of Copper. We ſhall have occaſion to be more particular on this ſubject when we come to treat of Lead.

Copper is ſoluble in all the acids, to which it communicates a green colour, and ſometimes a blue. Even the neutral ſalts, and water itſelf, act upon this metal. With regard to water indeed, as the procuring it abſolutely pure and free from any ſaline mixture is next to an impoſſibility, it remains a queſtion whether the effect it produces on Copper be not owing to certain ſaline particles contained in it. It is this great facility of being diſſolved that renders Copper ſo ſubject to ruſt; which is nothing elſe but ſome parts of its ſurface corroded by ſaline particles contained in the ſurrounding air and water.

The ruſt of Copper is always green or blue, or of a colour between theſe two. Internally uſed it is very noxious, being a real poiſon, as are all the ſolutions of this metal made by any acid whatever. The blue colour which Copper conſtantly aſſumes, when corroded by any ſaline ſubſtance, is a ſure ſign by which it may be diſcovered wherever it exiſts, even in a very ſmall quantity.

Copper diſſolved in the vitriolic acid forms a kind of metalline ſalt, which ſhoots into rhomboidal cryſtals of a moſt beautiful blue colour. Theſe cryſtals are called *Blue Vitriol*, or *Vitriol of Copper*. They are ſometimes found ready formed in the bowels of the earth; and may be artificially made by diſſolving Copper in the vitriolic acid; but the ſolution will not ſucceed unleſs the acid be well dephlegmated. The taſte of this vitriol is ſaltiſh and aſtringent. It retains a conſiderable quantity of water in cryſtallizing, on which account it is eaſily rendered fluid by fire.

It muſt be obſerved, that, when it is expoſed to a certain degree of heat, in order to free it of its humidity, a great part of its acid flies off at the ſame time: and hence it is that, after calcination, there remains only a kind of earth, or metalline calx, of a red colour, which contains but very little acid. This earth cannot be brought to flow but with the greateſt difficulty.

A ſolution of Copper in the nitrous acid forms a ſalt which does not cryſtallize, but, when dried, powerfully attracts the moiſture of the air. The ſame thing happens when it is diſſolved in the ſpirit of ſalt, or in *aqua regis*.

If the Copper thus diſſolved by any of theſe acids be precipitated by an earth or an alkali, it retains nearly the colour it had in the ſolution: but theſe precipitates are ſcarce any thing more than the earth of Copper, or Copper deprived of moſt of its phlogiſton; ſo that if they were expoſed to a violent fire, without any additament, a great part of them would be converted into an earth that could never be reduced to a metalline form. Therefore, when we intend to reduce theſe precipitates to Copper, it is neceſſary to add a certain quantity of a ſubſtance capable of reſtoring to them the phlogiſton they have loſt.

The ſubſtance which hath been found fitteſt for ſuch reductions is charcoal-duſt; becauſe charcoal is nothing but a phlogiſton cloſely combined with an earth, which renders it exceedingly fixed, and capable of reſiſting a violent force of fire. But as charcoal will not melt, and conſequently is capable of preventing rather than forwarding the flux of a metalline calx or glaſs, which nevertheleſs is eſſentially neceſſary to complete the reduction, it hath been contrived to mix it, or any other ſubſtance containing the phlogiſton, with ſuch fixed alkalis as eaſily flow, and are fit to promote the flux of other bodies. Theſe mixtures are called *Reducing Fluxes;* becauſe the general name of *Fluxes* is given to all ſalts or mixtures of ſalts, which facilitate fuſion.

If Sulphur be applied to Copper made perfectly red-hot, the metal immediately runs; and theſe two ſubſtances uniting form a new compound much more fuſible than pure Copper.

This compound is deſtroyed by the ſole force of fire, for two reaſons: the firſt is, that, ſulphur being volatile, the fire is capable of ſubliming a great part of it, eſpecially when it is in a great proportion to the Copper with which it is joined; the ſecond is, that the portion of ſulphur which remains, being more intimately united with the Copper, though it be rendered leſs combuſtible by that union, is nevertheleſs burnt and conſumed in time. Copper being combined with ſulphur, and together with it expoſed to the force of fire, is found to be partly changed into a blue vitriol; becauſe the vitriolic acid, being diſengaged by burning the ſulphur, is by that means qualified to diſſolve the Copper. The affinity of Copper with ſulphur is greater than that of Silver.

This metal, as well as the other imperfect metals and the ſemi-metals, being mingled with nitre and expoſed to the fire, is decompoſed and calcined much ſooner than by itſelf; becauſe the phlogiſton which it contains occaſions the deflagration of the nitre, and conſequently the two ſubſtances mutually decompoſe each other. There are certain metalline ſubſtances whoſe phlogiſton is ſo abundant, and ſo weakly connected with their earth, that when they are thus treated with nitre, there ariſes immediately a detonation, accompanied with flame, and as violent as if ſulphur or charcoal-duſt had been employed; ſo that in a moment the metalline ſubſtance loſes its phlogiſton, and is calcined. The nitre, after theſe detonations, always aſſumes an alkaline character.

SECTION IV.

Of IRON.

Iron is lighter and leſs ductile than Copper; but it is much harder, and of more difficult fuſion.

It is the only body that has the property of being attracted by the magnet, which therefore ſerves to diſcover it wherever it is. But it muſt be obſerved, that it hath this property only when in its metalline ſtate, and loſes it when converted to an earth or calx. Hence very few Iron-ores are attracted by the load-ſtone: becauſe, for the moſt part, they are only ſorts of earths, which require a phlogiſton to be added before they can be brought to the form of true Iron.

When Iron hath undergone no other preparation but the fuſion which is neceſſary to ſmelt it from its ore, it is uſually quite brittle, and flies to pieces under the hammer: which ariſes in ſome meaſure from its containing a certain portion of unmetallic earth interpoſed between its parts. This we call *Pig Iron.*

By melting this a ſecond time it is rendered purer, and more free from heterogeneous matters: but ſtill, as its proper parts are probably not brought ſufficiently near, or cloſely enough united, till the Iron hath undergone ſome further preparation beſides that of fuſion, it ſeldom hath any degree of malleability.

The way to give it this property is to make it juſt red-hot, and then hammer it for ſome time in all directions; to the end that its parts may be properly united, incorporated, and welded together, and that the heterogeneous matters which keep them aſunder may be ſeparated. Iron made by this means as malleable as poſſible we call *Bar Iron*, or *Forged Iron.*

Bar Iron is ſtill harder to fuſe than Pig Iron: to make it flow requires the utmoſt force of fire.

Iron has the property of imbibing a greater quantity of phlogiſton than is neceſſary to give it the metalline form. It may be made to take in this ſuperabundant phlogiſton two ways: the firſt is by fuſing it again with matters that contain the phlogiſton; the ſecond is, by encompaſſing it with a quantity of ſuch matters, charcoal-duſt, for inſtance, and then expoſing it ſo encompaſſed, for a certain time, to a degree of fire barely ſufficient to keep it red-hot. This ſecond method, whereby one ſubſtance is incorporated with another by means of fire, but without fuſing either of them, is in general called *Cementation.*

Iron thus impregnated with an additional quantity of phlogiſton is called *Steel.* The hardneſs of Steel may be conſiderably augmented by *tempering* it; that is, by making it red-hot, and ſuddenly quenching it in ſome cold liquor. The hotter the metal, and the colder the liquor in which it is quenched, the harder will the Steel be. By this means tools are made, ſuch as files and ſheers, capable of cutting and dividing the hardeſt bodies, as glaſs, pebbles, and Iron itſelf. The colour of Steel is darker than that of Iron, and the facets which appear on breaking it are ſmaller. It is alſo leſs ductile and more brittle, eſpecially when tempered.

As Iron may be impregnated with an additional quantity of phlogiſton, and thereby converted into Steel, ſo may Steel be again deprived of that ſuperabundant phlogiſton, and brought back to the condition of Iron. This is effected by cementing it with poor earths, ſuch as calcined bones and chalk. By the ſame operation Steel may be *untempered;* nay, it will loſe the hardneſs it had acquired by tempering, if it be but made red-hot, and left to cool gradually. As Iron and Steel differ only in the reſpects we have here taken notice of, their properties being in all other reſpects the ſame, what follows is equally applicable to both.

Iron being expoſed to the action of fire for ſome time, eſpecially when divided into ſmall particles, ſuch as filings, is calcined and loſes its phlogiſton. By this means it turns to a kind of reddiſh yellow earth, which, on account of its colour, is called *Crocus Martis*, or *Saffron of Mars.*

This calx of Iron has the ſingular property of flowing in the fire with ſomewhat leſs difficulty than Iron itſelf; whereas every other metalline calx flows with leſs eaſe than the metal that produced it. It has moreover the remarkable property of uniting with the phlogiſton, and of being reduced to Iron without fuſion; requiring for that purpoſe only to be made red-hot.

Iron may be incorporated with Silver, and even with Gold, by means of certain operations. Under the article of Lead we ſhall ſee how it may be ſeparated from theſe metals.

The acids produce on it much the ſame effects as on Copper; every one of them acts upon it. Certain neutral ſalts, alkalis, and even water itſelf, are capable of diſſolving it; and hence it is alſo very ſubject to ruſt. The vitriolic acid diſſolves it with the greateſt eaſe: but the circumſtances which attend the ſolution thereof are different from thoſe with which the ſame Acid diſſolves Copper: for, 1. whereas the vitriolic acid muſt be concentrated to diſſolve Copper, it muſt on the contrary be diluted with water to diſſolve Iron, which it will not touch when well dephlegmated. 2. The vapours which riſe in this diſſolution are inflammable; ſo that if it be made in a ſmall-necked bottle, and the flame of a candle be applied to the mouth thereof, the vapours in the bottle take fire with ſuch rapidity as to produce a conſiderable exploſion.

This ſolution is of a beautiful green colour; and from this union of the vitriolic acid with Iron there reſults a neutral metalline ſalt, which has the property of ſhooting into cryſtals of a rhomboidal figure, and a green colour. Theſe cryſtals are called *Green Vitriol, Vitriol of Mars,* and *Copperas.*

Green Vitriol hath a ſaltiſh and aſtringent taſte. As it retains a great deal of water in cryſtallizing, it quickly flows by the action of fire: but this fluidity is owing to its water only, and is not a real fuſion; for, as ſoon as its moiſture is evaporated, it reſumes a ſolid form. Its green tranſparent colour is now changed into an opaque white: and, if the calcination be continued, its acid alſo exhales and is diſſipated in vapours; and as it loſes that, it turns gradually to a yellow colour, which comes ſo much the nearer to a red the longer the calcination is continued, or the higher the force of the fire is raiſed; which being driven to the utmoſt, what remains is of a very deep red. This remainder is nothing but the body of the Iron, which having loſt its phlogiſton is now no more than an earth, nearly of the ſame nature with that which is left after calcining the metal itſelf.

Green Vitriol diſſolved in water ſpontaneouſly lets fall a yellowiſh earthy ſediment. If this ſolution be defecated by filtration, it ſtill continues to depoſite ſome of the ſame ſubſtance, till the vitriol be wholly decompoſed. This ſediment is nothing but the earth of Iron, which is then called *Ochre*.

The nitrous acid diſſolves Iron with great eaſe. This ſolution is of a yellow colour, inclining more or leſs to a ruſſet, or dark-brown, as it is more or leſs ſaturated with Iron. Iron diſſolved by this acid, alſo, falls ſpontaneouſly in a kind of calx, which is incapable of being diſſolved a ſecond time; for the nitrous acid will not act upon Iron that has loſt its phlogiſton. This ſolution does not cryſtallize, and if evaporated to dryneſs attracts the moiſture of the air.

Spirit of ſalt likewiſe diſſolves Iron, and this ſolution is green. The vapours which riſe during the diſſolution are inflammable, like thoſe which aſcend when this metal is attacked by the vitriolic acid. *Aqua regis* makes a ſolution of Iron, which is of a yellow colour.

Iron hath a greater affinity than either Silver or Copper with the nitrous and vitriolic acids: ſo that if iron be preſented to a ſolution of either in one of theſe two acids, the diſſolved metal will be precipitated; becauſe the acid quits it for the Iron, with which it has a greater affinity.

On this occaſion it muſt be obſerved, that if a ſolution of Copper in the vitriolic acid be precipitated by means of Iron, the precipitate has the form and ſplendour of a metal, and does not require the addition of a phlogiſton to reduce it to true Copper; which is not the caſe, as has been ſhewn, when the precipitation is effected by earths or alkaline ſalts.

The colour of this metalline precipitate hath deceived ſeveral perſons, who being unacquainted with ſuch phenomena, and with the nature of blue vitriol, imagined that Iron was tranſmuted into Copper, when they ſaw a bit of Iron laid in a ſolution of that vitriol become, in form and external appearance, exactly like Copper: whereas the ſurface only of the Iron was cruſted over with the particles of Copper contained in the vitriol, which had gradually fallen upon and adhered to the Iron, as they were precipitated out of the ſolution.

Among the ſolvents of Iron we mentioned fixed alkalis; and that they have ſuch a power is proved by the following phenomenon. If a large proportion of alkaline ſalts be ſuddenly mixed with a ſolution of Iron in an acid, no precipitation enſues, and the liquor remains clear and pellucid; or if at firſt it look a little turbid, that appearance laſts but a moment, and the liquor preſently recovers its tranſparency. The reaſon is, that the quantity of alkali is more than ſufficient to ſaturate all the acid of the ſolution, and the ſuperabundant portion thereof, meeting with the Iron already finely divided by the acid, diſſolves it with eaſe as faſt as it falls, and ſo prevents its muddying the liquor. To evince that this is ſo in fact, let the alkali be applied in a quantity that is not ſufficient, or but barely ſufficient, to ſaturate the acid, and the Iron will then precipitate like any other metal.

Water alſo acts upon Iron; and therefore Iron expoſed to moiſture grows ruſty. If iron-filings be expoſed to the dew, they turn wholly to a ruſt, which is called *Crocus Martis Aperiens*.

Iron expoſed to the fire together with nitre makes it detonate pretty briſkly, ſets it in a flame, and decompoſes it with rapidity.

This metal hath a greater affinity than any other metalline ſubſtance with ſulphur; on which account it is ſucceſsfully uſed to precipitate and ſeparate all metalline ſubſtances combined with ſulphur.

Sulphur uniting with Iron communicates to it ſuch a degree of fuſibility, that if a maſs of this metal heated red-hot be rubbed with a bit of ſulphur, it inceſſantly runs into as perfect a fuſion as a metal expoſed to the focus of a large burning-glaſs.

SECTION V.

Of TIN.

TIN is the lighteſt of all metals. Though it yields eaſily to the impreſſion of hard bodies, it has but little ductility. Being bent backwards and forwards it makes a ſmall crackling noiſe. It flows with a very moderate degree of fire, and long before it comes to be red-hot. When it is in fuſion, its ſurface ſoon grows duſty, and there forms upon it a thin dark-coloured duſty pellicle, which is no other than a part of the Tin that has loſt its phlogiſton, or a calx of Tin. The metal thus calcined eaſily recovers its metalline form on the addition of a phlogiſton. If the calx of Tin be urged by a ſtrong fire it grows white, but the greateſt violence of heat will not fuſe it; which makes ſome Chymiſts conſider it as a calcinable or abſorbent earth, rather than a vitrifiable one. Yet it turns to glaſs, in ſome ſort, when mixed with any other ſubſtance that vitrifies eaſily. However, it always produces an imperfect glaſs only, which is not at all tranſparent, but of an opaque white. The calx of Tin thus vitrified is called *Enamel*. Enamels are made of ſeveral colours by the addition of this or that metalline calx.

Tin unites eaſily with all the metals; but it deſtroys the ductility and malleability of every one of them, Lead excepted. Nay, it poſſeſſes this property of making metals brittle in ſuch an eminent degree, that the very vapour of it, when in fuſion, is capable of producing this effect. Moreover, which is very ſingular, the moſt ductile metals, even Gold and Silver, are thoſe on which it works this change with the moſt eaſe, and in the greateſt degree. It has alſo the property of making Silver mixed with it flow over a very ſmall fire.

It adheres to, and in ſome meaſure incorporates with, the ſurface of Copper and of Iron; whence aroſe the practice of coating over thoſe metals with Tin. Tin plates are no other than thin plates of Iron tinned over.

If to twenty parts of Tin one part of Copper be added, this alloy renders it much more ſolid, and the mixed maſs continues tolerably ductile.

If, on the contrary, to one part of Tin ten parts of Copper be added, together with a little Zink, a ſemi-metal to be conſidered hereafter, from this combination there reſults a metalline compound which is hard, brittle, and very ſonorous;

ous; ſo that it is uſed for caſting bells: this compoſition is called *Bronze* and *Bell-metal*.

Tin hath an affinity with the vitriolic, nitrous, and marine acids. All of them attack and corrode it; yet none of them is able to diſſolve it without great difficulty: ſo that if a clear ſolution thereof be deſired, particular methods muſt be employed for that purpoſe; for the acids do but in a manner calcine it, and convert it to a kind of white calx or precipitate. The ſolvent which has the greateſt power over it is *aqua regis*, which has even a greater affinity therewith than with Gold itſelf; whence it follows, that Gold diſſolved in *aqua regis* may be precipitated by means of Tin; but then the *aqua regis* muſt be weakened. Gold thus precipitated by Tin is of a moſt beautiful colour, and is uſed for a red in enameling and painting on porcelain, as alſo to give a red colour to artificial gems. If the *aqua regis* be not lowered, the precipitate will not have the purple colour.

Tin hath the property of giving a great luſtre to all red colours in general; on which account it is uſed by the dyers for ſtriking a beautiful ſcarlet, and tin veſſels are employed in making fine ſyrup of violets. Water does not act upon this metal, as it does upon Iron and Copper; for which reaſon it is not ſubject to ruſt: nevertheleſs, when it is expoſed to the air, its ſurface ſoon loſes its poliſh and ſplendour.

Tin mixed with nitre and expoſed to the fire deflagrates with it, makes it detonate, and is immediately converted to a *refractory calx:* for ſo all ſubſtances are called which are incapable of fuſion.

Tin readily unites with ſulphur, and with it becomes a brittle and friable maſs.

SECTION VI.

Of LEAD.

NEXT to Gold and Mercury Lead is the heavieſt of all metalline ſubſtances, but in hardneſs is exceeded by every one of them. Of all metals alſo it melts the eaſieſt except Tin. While it is in fuſion there gathers inceſſantly on its ſurface, as on that of Tin, a blackiſh duſty pellicle, which is nothing but a calx of Lead.

This calx further calcined by a moderate fire, the flame being reverberated on it, ſoon grows white. If the calcination be continued it becomes yellow, and at laſt of a beautiful red. In this ſtate it is called *Minium*, and is uſed as a pigment. *Minium* is not eaſily made, and the operation ſucceeds well in large manufactures only.

To convert Lead into *Litharge*, which is the metal in a manner half vitrified, you need only keep it melted by a pretty ſtrong fire; for then as its ſurface gradually calcines, it tends more and more to fuſion and vitrification.

All theſe preparations of Lead are greatly diſpoſed to perfect fuſion and vitrification, and for that purpoſe require but a moderate degree of fire; the calx or earth of Lead being of all metalline earths that which vitrifies the moſt eaſily.

Lead hath not only the property of turning into glaſs with the greateſt facility, but it hath alſo that of promoting greatly the vitrification of all the other imperfect metals; and, when it is actually vitrified, procures the ready fuſion of all earths and ſtones in general, even thoſe which are refractory, that is, which could not be fuſed without its help.

Glaſs of Lead, beſides its great fuſibility, hath alſo the ſingular property of being ſo ſubtile and active as to corrode and penetrate the crucibles in which it is melted, unleſs they be of an earth that is exceeding hard, compact, and withal very refractory: for Glaſs of Lead being one of the moſt powerful fluxes that we know, if the earth of the crucible in which it is melted be in the ſmalleſt degree fuſible, it will be immediately vitrified; eſpecially if there be any metallic matter in its compoſition.

The great activity of Glaſs of Lead may be weakened by joining it with other vitrifiable matters: but unleſs theſe be added in a very great proportion, it will ſtill remain powerful enough to penetrate common earths, and carry off the matters combined with it.

On theſe properties of Lead, and of the Glaſs of Lead, depends the whole buſineſs of refining Gold and Silver. It hath been ſhewn, that as theſe two metals are indeſtructible by fire, and the only ones which have that advantage, they may be ſeparated from the imperfect metals, when mixed therewith, by expoſing the compound to a degree of fire ſufficiently ſtrong to vitrify the latter; which, when once converted into glaſs, can no longer remain united with any metal that has its metalline form. But it is very difficult to procure this vitrification of the imperfect metals, when united with Gold and Silver; nay, it is in a manner impoſſible to vitrify them entirely, for two reaſons: firſt, becauſe moſt of them are naturally very difficult to vitrify; ſecondly, becauſe the union they have contracted with the perfect metals defends them, in a manner, from the action of the fire, and that ſo much the more effectually as the proportion of the perfect metals is greater; which being indeſtructible, and in ſome ſort coating over thoſe with which they are alloyed, ſerve them as a preſervative and impenetrable ſhield againſt the utmoſt violence of fire.

It is therefore clear, that a great deal of labour may be ſaved, and that Gold and Silver may be refined to a much greater degree of purity than can otherwiſe be obtained, if to a mixture of theſe metals with Copper, for inſtance, or any other imperfect metal be added a certain quantity of Lead. For the Lead, by its known property, will infallibly produce the deſired vitrification; and as it likewiſe increaſes the proportion of the imperfect metals, and ſo leſſens that of the perfect metals, in the maſs, it evidently deprives the former of a part of their guard, and ſo effects a more complete vitrification. In concluſion, as the Glaſs of Lead hath the property of running through the crucible, and carrying with it the matters which it has vitrified, it follows, that, when the vitrification of the imperfect metals is effected by its means, all thoſe vitrified matters together penetrate the veſſel containing the fuſed metalline maſs, diſappear, and leave only the Gold and Silver perfectly pure, and freed, as far as is poſſible, from all admixture of heterogeneous parts.

The better to promote the ſeparation of ſuch parts it is uſual to employ, in this proceſs, a particular ſort of ſmall crucibles, made of the aſhes of calcined bones, which are exceedingly porous and eaſily pervaded. They are called *cupels*, on account of their figure, which is that of a wide-mouthed cup: and from hence the operation takes its name; for when we refine Gold and Silver in this manner we are ſaid to *cupel* thoſe metals. It is eaſy to perceive that the more Lead is added the more accurately will the Gold and Silver be refined; and that ſo much the more Lead ought to be added as the perfect metals are alloyed with a greater proportion of the imperfect. This is the moſt ſevere trial to which a perfect metal can be put; and conſequently any metal that ſtands it may be fairly conſidered as ſuch.

In order to denote the fineneſs of Gold, it is ſuppoſed to be divided into twenty-four parts called *carats;* and Gold which is quite pure and free from all alloy is ſaid to be twenty-four *carats fine;* that which contains $\frac{1}{24}$ part of alloy is called Gold of twenty-three carats; that which contains $\frac{2}{24}$ of alloy is but twenty-two carats; and ſo on. Silver again is ſuppoſed to be divided into twelve parts only, which are called *penny-weights*: ſo that when abſolutely pure it is ſaid to be twelve *penny-weights fine*; when it contains $\frac{1}{12}$ of alloy, it is then called eleven penny-weights fine; when it contains $\frac{2}{12}$ of alloy, it is called ten penny-weights fine, and ſo on.

In treating of Copper we promiſed to ſhew, under the article of Lead, how to ſeparate it from Iron. The proceſs is founded on that property of Lead which renders it incapable of mixing and uniting with Iron, though it readily diſſolves all other metalline ſubſtances. Therefore, if you have a maſs compounded of Copper and Iron, it muſt be fuſed with a certain quantity of Lead, and then the Copper, having a greater affinity with Lead than with Iron, will deſert the latter and join the former, which being incapable of any union with Iron, as was ſaid, will wholly exclude it from the new compound. The next point is to ſeparate the Lead from the Copper; which is done by expoſing the maſs compounded of theſe two metals to a degree of fire ſtrong enough to deprive the Lead of its metalline form, but too weak to have the ſame effect on the Copper: and this may be done; ſince, of all the imperfect metals, Lead is, next to Tin, the eaſieſt to be calcined, and Copper on the contrary reſiſts the greateſt force of fire longeſt, without loſing its metalline form. Now what we gain by this exchange, viz. by ſeparating Copper from Iron and uniting it with Lead, conſiſts in this, that as Lead is calcined with leſs fire than Iron, the Copper is leſs expoſed to be deſtroyed: for it muſt be obſerved that, however moderate the fire be, it is hardly poſſible to prevent a certain quantity thereof from being calcined in the operation.

Lead melted with a third part of Tin forms a compound, which being expoſed to a fire capable of making it thoroughly red-hot, ſwells, puffs up, ſeems in ſome ſort to take fire, and is preſently calcined. Theſe two metals mixed together are much ſooner calcined than either of them ſeparately.

Both Lead and Tin are in ſome meaſure affected by water, and by a moiſt air; but they are both much leſs ſubject than Iron or Copper to be corroded by theſe ſolvents, and of courſe are much leſs liable to ruſt.

The vitriolic acid acts upon and diſſolves Lead, much in the ſame manner as it doth Silver.

The nitrous acid diſſolves this metal with much eaſe, and in great quantities; and from this ſolution a ſmall portion of Mercury may be obtained. On this ſubject ſee our *Elements of the Practice of Chymiſtry*.

When this ſolution of Lead is diluted with a good deal of water, the Lead precipitates in the form of a white powder; which happens becauſe the acid is rendered too weak to keep the Lead diſſolved.

If this ſolution of Lead be evaporated to a certain degree, it ſhoots into cryſtals formed like regular pyramids with ſquare baſes. Theſe cryſtals are of a yellowiſh colour, and a ſaccharine taſte: they do not eaſily diſſolve in water. This nitrous metalline ſalt has the ſingular property of detonating in a crucible, without any additament, or the contact of any other inflammable ſubſtance. This property it derives from the great quantity of phlogiſton contained in, and but looſely connected with, the Lead which is one of its principles.

If ſpirit of ſalt, or even ſea-ſalt in ſubſtance, be added to a ſolution of Lead in the nitrous acid, a white precipitate immediately falls; which is no other than the Lead united with the marine acid. This precipitate is extremely like the precipitate of Silver made in the ſame manner, and that being called *Luna cornea* hath occaſioned this to be named *Plumbum corneum*. Like the *luna cornea* it is very fuſible, and being melted hardens like it into a kind of horny ſubſtance: it is volatile, and may be reduced by means of inflammable matters combined with alkalis. But it differs from the *luna cornea* in this chiefly, that it diſſolves eaſily in water; whereas the *luna cornea*, on the contrary, diſſolves therein with great difficulty, and in a very ſmall quantity.

As this precipitation of Lead from its ſolution in ſpirit of nitre is procured by the marine acid, Lead is thereby proved to have a greater affinity with the latter acid than with the former. Yet, if you attempt to diſſolve Lead directly by the acid of ſea-ſalt, the ſolution is not ſo eaſily effected as by the ſpirit of nitre, and it is always imperfect; for it wants one of the conditions eſſential to every ſolution in a liquor, namely tranſparency.

If Lead be boiled for a long time in a lixivium of fixed alkali, part of it will be diſſolved.

Sulphur renders this metal refractory and ſcarce fuſible; and the maſs they form when united together is friable. Hence it appears that ſulphur acts upon Lead much in the ſame manner as upon Tin; that is, it renders both theſe metals leſs fuſible, which are naturally the moſt fuſible of any, while it exceedingly facilitates the fuſion of Silver, Copper, and Iron, metals which of themſelves flow with the greateſt difficulty.

CHAP. VIII.

Of QUICK-SILVER.

WE treat of Quick-ſilver in a chapter apart, becauſe this metallic ſubſtance cannot be claſſed with the metals properly ſo called, and yet has ſome properties which will not allow us to confound it with the ſemi-metals. The reaſon why Quick-ſilver, by the Chymiſts commonly called Mercury, is not reputed a metal, is, that it wants one of the eſſential properties thereof, to wit, malleability. When it is pure and unadulterated with any mixture, it is always fluid, and of courſe unmalleable. But as, on the other hand, it eminently poſſeſſes the opacity, the ſplendour, and, above all, the gravity of a metal, being next to Gold the heavieſt of all bodies, it may be conſidered as a true metal, differing from the reſt no otherwiſe than by being conſtantly in fuſion; which we may ſuppoſe ariſes from its aptneſs to flow with ſuch a ſmall degree of heat, that be there ever ſo little warmth on earth, there is ſtill more than enough to keep Mercury in fuſion; which would become ſolid and malleable if it were poſſible to apply to it a degree of cold conſiderable enough for that purpoſe. Theſe properties will not allow us to confound it with the ſemi-metals. Add, that we are not yet aſſured by any undoubted experiment that it can be wholly deprived of its phlogiſton, as the imperfect metals may. Indeed we cannot apply the force of fire to it as could be wiſhed: for it is ſo volatile that it flies off and exhales in vapours, with a much leſs degree of fire than is neceſſary to make it red-hot. The vapours of Mercury thus raiſed by the action of fire, being collected and united in a certain quantity, appear to be no other than true Mercury, retaining every one of its properties; and no experiment hath ever been able to ſhew the leaſt change thus produced in its nature.

If Mercury be expoſed to the greateſt heat that it can bear without ſublimation, and continued in it for ſeveral months, or even a whole year together, it turns to a red powder, which the Chymiſts call *Mercurius Præcipitatus per ſe.*

But, to ſucceed in this operation, it is abſolutely neceſſary that the heat be ſuch as is above-ſpecified; for this metallic ſubſtance may remain expoſed to a weaker heat for a conſiderable number of years, without undergoing any ſenſible alteration.

Some Chymiſts fancied, that by this operation they had fixed Mercury and changed its nature; but without any reaſon: for if the Mercury thus ſeemingly tranſmuted be expoſed to a ſomewhat ſtronger degree of fire, it ſublimes and exhales in vapours as uſual; and thoſe vapours collected are nothing elſe but running Mercury, which has recovered all its properties without the help of any additament.

Mercury has the property of diſſolving all the metals, Iron only excepted. But it is a condition abſolutely neceſſary to the ſucceſs of ſuch diſſolution, that the metalline ſubſtances be poſſeſſed of their phlogiſton; for if they be calcined, Mercury cannot touch them: and hence it follows, that Mercury doth not unite with ſubſtances that are purely earthy. Such a combination of a metal with Mercury is called an *Amalgam.* Trituration alone is ſufficient to effect it; however, a proper degree of heat alſo is of uſe.

Mercury amalgamated with a metal gives it a conſiſtence more or leſs ſoft, and even fluid, according to the greater or ſmaller proportion of Mercury employed. All amalgams are ſoftened by heat, and hardened by cold.

Mercury is very volatile; vaſtly more ſo than the moſt unfixed metals; moreover, the union it contracts with any metal is not ſufficiently intimate to entitle the new compound reſulting from that union to all the properties of the two ſubſtances united: at leaſt with regard to their degree of fixity and volatility. From all which it follows, that the beſt and ſureſt method of ſeparating it from metals diſſolved by it, is to expoſe the amalgam to a degree of heat ſufficient to make all the Quick-ſilver riſe and evaporate; after which the metal remains in the form of a powder, and being fuſed recovers its malleability. If it be thought proper to ſave the Quick-ſilver, the operation muſt be performed in cloſe veſſels, which will confine and collect the mercurial vapours. This operation is moſt frequently employed to ſeparate Gold and Silver from the ſeveral ſorts of earths and ſands with which they are mixed in the ore; becauſe theſe two metals, Gold eſpecially, are of ſufficient value to compenſate the loſs of Mercury, which is inevitable in this proceſs: beſides, as they very readily amalgamate with it, this way of ſeparating them from every thing unmetallic is very facile and commodious.

Mercury is diſſolved by acids; but with circumſtances peculiar to each particular ſort of acid.

The vitriolic acid, concentrated and made boiling hot, ſeizes on it, and preſently reduces it to a kind of white powder, which turns yellow by the affuſion of water, but does not diſſolve in it; it is called *Turbith Mineral.* However, the vitriolic acid on this occaſion unites with a great part of the Mercury, in ſuch a manner that the compound is ſoluble in water. For if to the water which was uſed to waſh the Turbith a fixed alkali be added, there falls inſtantly a ruſſet-coloured precipitate, which is no other than Mercury ſeparated from the vitriolic acid by the intervention of the alkali.

This diſſolution of Mercury by the vitriolic acid is accompanied with a very remarkable phenomenon; which is, that the acid contracts a ſtrong ſmell of volatile ſpirit of ſulphur: a notable proof that part of the phlogiſton of the Mercury hath united therewith. And yet, if the Mercury be ſeparated by means of a fixed alkali, it does not appear to have ſuffered any alteration. Turbith mineral is not ſo volatile as pure Mercury.

The nitrous acid diſſolves Mercury with eaſe. The ſolution is limpid and tranſparent, and as it grows cold ſhoots into cryſtals, which are a nitrous mercurial ſalt.

If this ſolution be evaporated to dryneſs, the Mercury remains impregnated with a little of the acid, under the form of a red powder, which hath obtained the names of *Red Precipitate*, and *Arcanum Corallinum.* This Precipitate, as well as Turbith, is leſs volatile than pure Mercury.

If this ſolution of Mercury be mixed with a ſolution of Copper, made likewiſe in the nitrous acid, and the mixture evaporated to dryneſs, there will remain a green powder called *Green Precipitate.* Theſe precipitates are cauſtic and corroſive; and are uſed as ſuch in ſurgery.

Though Mercury be diſſolved more eaſily and completely by the nitrous acid than by the vitriolic, yet it has a greater affinity with the latter than with the former: for if a vitriolic acid be poured into a ſolution of Mercury in ſpirit of nitre, the Mercury will quit the latter acid in which it was diſſolved, and join the other which was added. The ſame thing happens when the marine acid is employed inſtead of the vitriolic.

Mercury combined with ſpirit of ſalt forms a ſingular body; a metalline ſalt which ſhoots into long cryſtals, pointed like daggers. This ſalt is volatile, and ſublimes eaſily without decompoſition. It is moreover the moſt violent of all the corroſives hitherto diſcovered by Chymiſtry. It is called *Corroſive Sublimate*, becauſe it muſt abſolutely be ſublimed to make the combination perfect. There are ſeveral ways of doing this: but the operation will never fail, if the Mercury be rarefied into vapours, and meet with the marine acid in a ſimilar ſtate.

Corroſive Sublimate is diſſolved by water, but in very ſmall quantities only. It is decompounded by fixed alkalis, which precipitate the Mercury in a reddiſh yellow powder, called, on account of its colour, *Yellow Precipitate.*

If Corroſive Sublimate be mixed with tin, and the compound diſtilled, a liquor comes over which continually emits abundance of denſe fumes, and, from the name of its inventor, is called the *Smoking Liquor of Libavius.* This liquor is no other than the tin combined with the marine acid of the Corroſive Sublimate, which therefore it hath actually decompounded: whence it follows, that this acid hath a greater affinity with tin than with Mercury.

The marine acid in Corroſive Sublimate is not quite ſaturated with Mercury; but is capable of taking up a much greater quantity thereof. For if Corroſive Sublimate be mixed with freſh Mercury, and ſublimed a ſecond time, another compound will be produced containing much more Mercury, and leſs acrimonious; for which reaſon it is named *Sweet Sublimate of Mercury*, *Mercurius dulcis*, *Aquila alba.* This compound may be taken internally, and is purgative or emetic according to the doſe adminiſtered. It may be rendered ſtill more gentle by repeated ſublimations, and then it takes the title of *Panacea Mercurialis.* No way hath hitherto been found to diſſolve Mercury in *aqua regis* without great difficulty, and even then it is but imperfectly diſſolved.

Mercury unites eaſily and intimately with ſulphur If theſe two ſubſtances be only rubbed together in a gentle heat, or even without any heat, they will contract an union, though but an incomplete one. This combination takes the form of a black powder, which has procured it the name of *Æthiops Mineral.*

If a more intimate and perfect union be deſired, this compound muſt be expoſed to a ſtronger heat; and then a red ponderous ſubſtance will be ſublimed, appearing like a maſs of ſhining needles: this is the combination deſired, and is called *Cinabar.* In this form chiefly is Mercury found in the bowels of the earth. Cinabar finely levigated acquires a much brighter red colour, and is known to painters by the name of *Vermilion.*

Cinabar riſes wholly by ſublimation, without ſuffering any decompoſition; becauſe the two ſubſtances of which it conſiſts, *viz.* Mercury and Sulphur, are both volatile.

Though Mercury unites and combines very well with ſulphur, as hath been ſaid, yet it hath leſs affinity with that mineral than any other metal, Gold only excepted: whence it follows, that any of the other metals will decompound Cinabar, by uniting with its ſulphur, and ſo ſetting the Mercury at liberty to appear in its uſual form. Mercury thus ſeparated from ſulphur is eſteemed the pureſt, and bears the name of *Mercury revivified from Cinabar.*

Iron is generally uſed in this operation, preferably to the other metals, becauſe among them all it has the greateſt affinity with ſulphur, and is the only one that has none with Mercury.

Cinabar may alſo be decompounded by means of fixed alkalis; the affinity of theſe ſalts with ſulphur being generally greater than that of any metalline ſubſtance whatever.

CHAP. IX.

Of the SEMI-METALS.

SECTION I.

Of REGULUS OF ANTIMONY.

REGULUS of Antimony is a metallic ſubſtance of a pretty bright white colour. It has the ſplendour, opacity, and gravity of a metal: but it is quite unmalleable, and crumbles to duſt, inſtead of yielding or ſtretching, under the hammer; on which account it is claſſed with the Semimetals.

It begins to flow as ſoon as it is moderately red; but, like the other Semi-metals, it cannot ſtand a violent degree of fire; being thereby diſſipated into ſmoke and white vapours, which adhere to ſuch cold bodies as they meet with, and ſo are collected into a kind of *farina* called *Flowers of Antimony.*

If Regulus of Antimony, inſtead of being expoſed to a ſtrong fire, be only heated ſo moderately that it ſhall not even melt, it will calcine, loſe its phlogiſton, and take the form of a greyiſh powder deſtitute of all ſplendour: this powder is called *Calx of Antimony.*

This calx is not volatile like the Regulus, but will endure a very violent fire; and being expoſed thereto will flow, and turn to a glaſs of the yellowiſh colour of a hyacinth.

It is to be obſerved, that the more the Regulus is deprived of its phlogiſton by continued calcination, the more refractory is the calx obtained from it. The glaſs thereof has alſo ſo much the leſs colour, and comes the nearer to common glaſs.

The calx and the Glaſs of Antimony will recover their metalline form, like every other Calx and Glaſs of a metal, if reduced by reſtoring to them their loſt phlogiſton. Yet if the calcination be carried too far, their reduction will become much more difficult, and a much ſmaller quantity of Regulus will be reſuſcitated.

Regulus of Antimony is capable of diſſolving the metals: but its affinities with them are various, and differ according to the following order. It affects Iron the moſt powerfully, next Copper, then Tin, Lead, and Silver. It promotes the fuſion of metals, but makes them all brittle and unmalleable.

It will not amalgamate with Mercury; and though by certain proceſſes, particularly the addition of water and continued trituration, a ſort of union between theſe two ſubſtances may be produced, yet it is but apparent and momentary; for, being left to themſelves and undiſturbed, they quickly diſunite and ſeparate *.

The vitriolic acid, aſſiſted by heat, and even by diſtillation, diſſolves Regulus of Antimony. The nitrous acid likewiſe attacks it: but the ſolution can by no art be made clear and limpid: ſo that the Regulus is only calcined, in a manner, by this acid.

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* M. Malouin, however, hath found a way to unite theſe two metallic ſubſtances: but then he does it by the interpoſition of ſulphur; that is, he combines crude Antimony with Mercury. This combination is brought about in the ſame way that Æthiops Mineral is made; *viz.* either by fuſion, or by trituration only without fire. It reſembles the common Æthiops, and M. Malouin calls it *Æthiops of Antimony.* He obſerved that Mercury unites with Antimony much more intimately, by melting, than by rubbing them together.

The marine acid diſſolves it well enough; but then it muſt be exceedingly concentrated, and applied in a peculiar manner, and eſpecially by diſtillation. One of the beſt methods of procuring a perfect union between the acid of ſea-ſalt and Regulus of Antimony, is to pulverize the latter, mix it with corroſive ſublimate, and diſtil the whole. There riſes in the operation a white matter, thick, and ſcarce fluid, which is no other than the Regulus of Antimony united and combined with the acid of ſea-ſalt. This compound is extremely corroſive, and is called *Butter of Antimony.*

It is plain that the corroſive ſublimate is here decompounded; that the Mercury is revivified, and that the acid which was combined therewith hath quitted it to join the Regulus of Antimony, with which its affinity is greater. This Butter of Antimony by repeated diſtillations acquires a conſiderable degree of fluidity and limpidneſs.

If the acid of nitre be mixed with Butter of Antimony, and the whole diſtilled, there riſes an acid liquor, or a ſort of *aqua regis*, which ſtill retains ſome of the diſſolved Regulus, and is called *Bezoardic Spirit of Nitre.* After the diſtillation there remains a white matter, from which freſh ſpirit of nitre is again abſtracted, and which being then waſhed with water is called *Bezoar Mineral.* This Bezoar Mineral is neither ſo volatile nor ſo cauſtic as Butter of Antimony; becauſe the nitrous acid hath not the property of volatilizing metallic ſubſtances, as the marine acid does, and becauſe it remains much more intimately combined with the reguline part.

If Butter of Antimony be mixed with water, the liquor immediately becomes turbid and milky, and a precipitate falls, which is nothing but the metallic matter partly ſeparated from its acid, which is too much weakened by the addition of water to keep it diſſolved. Yet this precipitate ſtill retains a good deal of acid; for which reaſon it continues to be a violent emetic, and in ſome degree corroſive. It hath therefore been very improperly called *Mercurius Vitæ.*

The proper ſolvent of Regulus of Antimony is *aqua regis;* by means whereof a clear and limpid ſolution of this Semi-metal may be obtained.

Regulus of Antimony mixed with nitre, and projected into a red-hot crucible, ſets the nitre in a flame, and makes it detonate. As it produces this effect by means of its phlogiſton, it muſt needs at the ſame time be calcined, and loſe its metallic properties, which accordingly happens, and when the nitre is in a triple proportion to the Regulus, the latter is ſo perfectly calcined as to leave only a white powder, which is fuſed with great difficulty, and then turns to a faintly coloured glaſs, not very different from common glaſs, and which is not reducible to a Regulus by the addition of inflammable matter; at leaſt it yields but a very ſmall quantity thereof. If leſs nitre be uſed, the calx is not ſo white; the glaſs it produces is more like a metalline glaſs, and is more eaſily reduced. The calx of the Regulus thus prepared by nitre is called, on account of the medicinal virtue aſcribed to it, *Diaphoretic Antimony*, or *Diaphoretic Mineral*.

Nitre always becomes an alkali by deflagration, and in the preſent caſe retains part of the calx, which it even renders ſoluble in water. This calx may be ſeparated from the alkali, if an acid be employed to precipitate it; and then it is called *Materia Perlata*. This pearly matter is a calx of Antimony, ſo completely deprived of its phlogiſton as to be altogether incapable of reduction to a Regulus.

Regulus of Antimony readily joins and unites with ſulphur, forming therewith a compound which has a very faint metallic ſplendour. This compound appears like a maſs of long needles adhering together laterally; and under this form it is uſually found in the ore, or at leaſt when only ſeparated by fuſion from the ſtones and earthy matters with which the ore is mixed. It is called *Crude Antimony*.

Antimony flows with a moderate heat, and becomes even more fluid than other metallic ſubſtances. The action of fire diſſipates or conſumes the ſulphur it contains, and its phlogiſton alſo, ſo as to convert it into a calx and a glaſs, as it does the Regulus.

Aqua regis, which we obſerved to be the proper ſolvent of the Regulus, being poured on Antimony, attacks and diſſolves the reguline part, but touches not the ſulphur; in conſequence whereof it decompoſes the Antimony, and ſeparates its ſulphur from its Regulus.

There are ſeveral other ways of effecting this decompoſition, and obtaining the reguline part of Antimony by itſelf: they conſiſt either in deſtroying the ſulphureous part of the Antimony by combuſtion, or in melting the Antimony with ſome ſubſtance which has a greater affinity than its reguline part with ſulphur. Moſt metals are very fit for this latter purpoſe: for though the Regulus has a conſiderable affinity with ſulphur, yet all the metals, except Gold and Mercury, have a greater.

If therefore Iron, Copper, Lead, Silver, or Tin, be melted with Antimony, the metal employed will unite with the ſulphur, and ſeparate it from the Regulus.

It muſt be obſerved, that, as theſe metals have ſome affinity with the Regulus of Antimony, the Regulus will be joined in the operation by ſome of the metal employed as a *Precipitant*, (ſo thoſe ſubſtances are called which ſerve as the means of ſeparating two bodies from each other); and therefore the Regulus procured in this manner will not be abſolutely pure: on this account care is taken to diſtinguiſh each by adding the name of the metal employed in its precipitation; and thence come theſe titles, *Martial Regulus of Antimony*, or only *Martial Regulus*, *Regulus Veneris*; and ſo of the reſt.

Antimony is employed with advantage to ſeparate Gold from all the other metals with which it may be alloyed. It has been ſhewn, that all the metals have a greater affinity than the reguline part of Antimony with ſulphur, Gold only excepted; which is incapable of contracting any union therewith: and therefore, if a maſs compounded of Gold and ſeveral other metals be melted with Antimony, every thing in that maſs which is not Gold will unite with the ſulphur of the Antimony. This union occaſions two ſeparations, to wit, that of the ſulphur of the Antimony from its reguline part, and that of the Gold from the metals with which it was adulterated; and from the whole two new compounds ariſe; namely, a combination of the metals with the ſulphur, which being lighteſt riſes to the ſurface in fuſion; and a metalline maſs, formed of the Gold and the reguline part of the Antimony united together, which being much the heavieſt ſinks to the bottom. There is no difficulty in parting the Gold from the Regulus of Antimony with which it is alloyed: for the metalline maſs needs only be expoſed to a degree of fire capable of diſſipating into vapours all the Semi-metal it contains; which being very volatile, the operation is much eaſier, and more expeditiouſly finiſhed, than if the metals with which the Gold was debaſed were to be vitrified on the cupel; without taking into the account, that, if Silver were one of them, recourſe muſt needs be had to the proceſs of quartation after that of the cupel.

If equal parts of nitre and Antimony be mixed together, and the mixture expoſed to the action of fire, a violent detonation enſues; the nitre deflagrating conſumes the ſulphur of the Antimony, and even a part of its phlogiſton. After the detonation there remains a greyiſh matter which contains fixed nitre, vitriolated tartar, and the reguline part of the Antimony in ſome meaſure deprived of its phlogiſton, and half vitrified by the action of the fire, which is conſiderably increaſed by the deflagration. This matter is called *Liver of Antimony*.

If, inſtead of equal parts of nitre and Antimony, two parts of the former be uſed to one of the latter, then the reguline part loſes much more of its phlogiſton, and remains in the form of a yellowiſh powder.

Again, if three parts of nitre be taken to one of Antimony, the Regulus is thereby entirely robbed of its phlogiſton, and converted to a white calx, which bears the name of *Diaphoretic Antimony*, or *Diaphoretic Mineral*. The pearly matter may be precipitated by pouring an acid on the ſaline ſubſtances which here remain after the detonation, in the ſame manner as we ſhewed above was to be done with regard to the Regulus.

In the two laſt operations, where the nitre is in a double or triple proportion to the Antimony, the reguline part is found after the detonation to be converted into a calx, and not into a half-vitrified matter, which we have ſeen is the effect when equal parts only of nitre and Antimony are uſed. The reaſon of this difference is, that in theſe two caſes the reguline part, being wholly, or almoſt wholly, deprived of its phlogiſton, becomes, as was obſerved, more difficult to fuſe, and conſequently cannot begin to vitrify in the ſame degree of heat as that which hath not loſt ſo much of its phlogiſton. If, inſtead of performing the operation with equal parts of nitre and Antimony alone, a portion of ſome ſubſtance which abounds with phlogiſton be added, in that caſe the ſulphur only of the Antimony will be conſumed, and the Regulus will remain united with its phlogiſton and ſeparated from its ſulphur.

The Regulus prepared in this manner is abſolutely pure, becauſe no metalline ſubſtance being employed, none can mix with and adulterate it. It is called *Regulus of Antimony per ſe*, or only *Regulus of Antimony*.

It is true indeed that in this operation much of the reguline part unavoidably loſes its phlogiſton and is calcined, and conſequently a much ſmaller quantity of Regulus is obtained than when metalline precipitants are employed: but this loſs is eaſily repaired, if it be thought proper, by reſtoring to the calcined part its loſt phlogiſton.

Antimony melted with two parts of fixed alkali yields no

Regulus, but is entirely diſſolved by the ſalt, and forms with it a maſs of a reddiſh yellow colour.

The reaſon why no precipitate is produced on this occaſion is, that the alkali uniting with the ſulphur of the Antimony forms therewith the combination called Liver of Sulphur, which by its nature is qualified to keep the reguline part diſſolved. This maſs formed by the union of the Antimony with the alkali is ſoluble in water. If any acid whatever be dropt into this ſolution, there falls a precipitate of a reddiſh yellow colour; becauſe the acid unites with the alkali, and forces it to quit the matters with which it was combined. This precipitate is called *Golden Sulphur of Antimony*.

As in the operation for preparing *Regulus of Antimony per ſe*, ſome of the nitre is, by the inflammable matters added thereto, turned to an alkali, this alkali ſeizes on part of the Antimony, and therewith forms a compound like that juſt deſcribed. Hence it comes, that if the ſcoria formed in this proceſs be diſſolved in water, and an acid dropped into the ſolution, a true golden ſulphur of Antimony is thereby ſeparated.

This union of Antimony with an alkali may alſo be brought about by the humid way; that is, by making uſe of an alkali reſolved into a liquor, and boiling the mineral in it. The alkaline liquor, in proportion as it acts upon the Antimony, gradually becomes reddiſh and turbid. If left to ſettle and cool when well ſaturated therewith, it gradually depoſites the Antimony it had taken up, which precipitates in the form of a red powder; and this precipitate is the celebrated remedy known by the name of *Kermes Mineral*. It is plain that the kermes is nearly the ſame thing with the golden ſulphur: yet it differs from it in ſome reſpects; and eſpecially in this, that being taken inwardly it operates much more gently than the golden ſulphur, which is a violent emetic. Nitre fixed by charcoal, and reſolved into a liquor, is the only alkali employed in preparing the kermes.

It was ſhewn above, that Regulus of Antimony mixed and diſtilled with corroſive ſublimate decompounds it, diſengages the Mercury, and joining itſelf to the marine acid forms therewith a new combination, called Butter of Antimony. If the ſame operation be performed with crude Antimony inſtead of its Regulus, the ſame effects are produced: but then the Antimony itſelf is alſo decompoſed; that is, the reguline part is ſeparated from the ſulphur, which being ſet free unites with the Mercury, now alſo at liberty, and theſe two together form a true cinabar, called *Cinabar of Antimony.*

SECTION II.

Of BISMUTH.

BISMUTH, known alſo by the name of Tin-glaſs, is a ſemi-metal, having almoſt the ſame appearance as Regulus of Antimony; yet it has a more duſky caſt, inclining ſomewhat to red, and even preſents ſome changeable ſtreaks, eſpecially after lying long in the air.

When expoſed to the fire it melts long before it is red, and conſequently with leſs heat than Regulus of Antimony, which does not flow, as was ſhewn above, till it begin to be red-hot. It becomes volatile, like all the other ſemi-metals, when acted on by a violent fire: being kept in fuſion by a proper degree of heat it loſes its phlogiſton with its metallic form, and turns to a powder or a calx; and that again is converted into glaſs by the continued action of fire. The calx and glaſs of Biſmuth may be reduced, like any other metallic calx, by reſtoring their phlogiſton.

Biſmuth mixes with all the metals in fuſion, and even facilitates the fuſion of ſuch as do not otherwiſe flow readily. It whitens them by its union, and deſtroys their malleability.

It amalgamates with Mercury, if they be rubbed together with the addition of water: yet after ſome time theſe two metalline ſubſtances deſert each other, and the Biſmuth appears again in the form of a powder. Hence it is plain, that the union it contracts with Mercury is not perfect; and yet it has the ſingular property of attenuating Lead, and altering it in ſuch a manner that it afterwards amalgamates with Mercury much more perfectly, ſo as even to paſs with it through ſhamoy leather without any ſeparation. The Biſmuth employed in making this amalgama afterwards ſeparates from it ſpontaneouſly, as uſual; but the Lead ſtill continues united with the Mercury, and always retains the property thus acquired.

The vitriolic acid does not diſſolve Biſmuth: its proper ſolvent is the nitrous acid, which diſſolves it with violence, and abundance of fumes.

Biſmuth diſſolved in the nitrous acid is precipitated not only by alkalis, but even by the bare addition of water. This precipitate is extremely white, and known by the name of *Magiſtery of Biſmuth.*

The acid of ſea-ſalt and *aqua regis* likewiſe act upon Biſmuth, but with leſs violence.

This ſemi-metal does not ſenſibly deflagrate with nitre; yet it is quickly deprived of its phlogiſton, and turned into a vitrifiable calx, when expoſed with it to the action of fire.

It readily unites with ſulphur in fuſion, and forms therewith a compound which appears to conſiſt of needles adhering laterally to each other.

It may be ſeparated from the ſulphur with which is is combined, by only expoſing it to the fire, without any additament; for the ſulphur is either conſumed or ſublimed, and leaves the Biſmuth behind.

SECTION III.

Of ZINC.

ZINC to appearance differs but little from Biſmuth, and has even been confounded with it by ſeveral authors. Nevertheleſs, beſides that it has ſomething of a blueiſh caſt, and is harder than Biſmuth, it differs from it eſſentially in its properties, as will preſently be ſhewn. Theſe two metallic ſubſtances ſcarce reſemble each other in any thing, but the qualities common to all ſemi-metals.

Zinc melts the moment it grows red in the fire, and then alſo begins to turn to a calx, which, like any other metallic calx, may be reduced by means of the phlogiſton: but if the fire be conſiderably increaſed, it ſublimes, flames, and burns like an oily matter; which is a proof of the great quantity of phlogiſton in its compoſition. At the ſame time abundance of flowers riſe from it in the form of white flakes, flying about in the air like very light bodies; and into this form may the whole ſubſtance of the Zinc be converted. Several names have been given to theſe flowers, ſuch as Pompholyx, Philoſophic Wool. They are ſuppoſed to be no other than the Zinc itſelf deprived of its phlogiſton; yet no body has hitherto been able to reſuſcitate them in the form of Zinc, by reſtoring their phlogiſton according to the methods uſed in the reduction of metals. Though they riſe in the air with very great eaſe while the Zinc is calcining, yet when once formed they are very fixed; for they withſtand the utmoſt violence of fire, and are capable of being vitrified, eſpecially if joined with a fixed alkali. They are ſoluble in acids.

Zinc unites with all metalline ſubſtances, except Biſmuth. It has this ſingular property, that being mixed with Copper, even in a conſiderable quantity, ſuch as a fourth part, it does not greatly leſſen the ductility thereof, and at the ſame time communicates to it a very beautiful colour not unlike that of Gold: on which account the compoſition is frequently made, and produces what is called *Braſs*. This metal melts much more eaſily than Copper alone, becauſe of the Zinc with which it is alloyed. If it be expoſed to a great degree of heat, the Zinc which it contains takes fire, and ſublimes in white flowers, juſt as when it is pure.

It is to be obſerved, that Braſs is ductile only while it is cold, and not then, unleſs the Zinc uſed in making it was very pure; otherwiſe the compoſition will prove but a *Tombac* or *Prince's Metal*, having very little malleability.

Zinc is very volatile, and carries off with it any metallic ſubſtance with which it is fuſed, making a kind of ſublimate thereof. In the furnaces where they ſmelt ores containing Zinc, the matter thus ſublimed is called *Cadmia Fornacum*, to diſtinguiſh it from the native *Cadmia* called alſo *Calamine*, or *Lapis Calaminaris*; which, properly ſpeaking, is an ore of Zinc, containing a great deal of that ſemi-metal, together with ſome Iron, and a ſtony ſubſtance. The name of *Cadmia Fornacum* is not appropriated ſolely to the metallic ſublimates procured by means of Zinc, but is given in general to all the metallic ſublimates found in ſmelting houſes.

If a violent and ſudden heat be applied to Zinc, it ſublimes in its metalline form; there not being time for it to burn and be reſolved into flowers.

This ſemi-metal is ſoluble in all the acids, but eſpecially in ſpirit of nitre, which attacks and diſſolves it with very great violence.

Zinc has a greater affinity than iron or copper with the vitriolic acid; and therefore it decompounds the green and blue vitriols, precipitating thoſe two metals by uniting with the vitriolic acid, with which it forms a metallic ſalt, or vitriol, called *White Vitriol*, or *Vitriol of Zinc*.

Nitre mixed with Zinc, and projected into a red-hot crucible, detonates with violence, and during the detonation there riſes a great quantity of white flowers, like thoſe which appear when it is calcined by itſelf.

Sulphur has no power over Zinc. Even liver of ſulphur, which diſſolves all other metallic ſubſtances, contracts no union with this ſemi-metal.

Meſſrs. Hellot and Malouin have beſtowed a great deal of pains on this ſemi-metal. An account of their experiments is to be found in the Memoirs of the Academy of Sciences.

SECTION IV.

Of REGULUS OF ARSENIC.

REGULUS of Arſenic is the moſt volatile of all the ſemi-metals. A very moderate heat makes it wholly evaporate, and fly off in fumes; on which account it cannot be brought to fuſion, nor can any conſiderable maſſes thereof be obtained. It has a metallic colour, ſomewhat reſembling Lead; but it ſoon loſes its ſplendour when expoſed to the air.

It unites readily enough with metallic ſubſtances, having the ſame affinities with them as Regulus of Antimony hath. It makes them brittle, and unmalleable. It hath alſo the property of rendering them volatile, and greatly facilitates their ſcorification.

It very eaſily parts with its phlogiſton and its metallic form. When expoſed to the fire it riſes in a kind of ſhining cryſtalline calx, which, on that account, looks more like a ſaline matter than a metallic calx. To this calx or theſe flowers are given the names of *White Arſenic*, *Cryſtalline Arſenic*, and moſt commonly plain *Arſenic*.

The properties of this ſubſtance are very ſingular, and extremely different from thoſe of any other metallic calx. Hitherto it hath been but little examined; and this led me to make ſome attempts towards diſcovering its nature, which may be ſeen in the Memoirs of the Academy of Sciences.

Arſenic differs from every other metalline calx, firſt, in being volatile; whereas the calces of all other metallic ſubſtances, not excepting thoſe of the moſt volatile ſemi-metals, ſuch as Regulus of Antimony and Zinc, are exceeding fixed; and, ſecondly, in having a ſaline character, which is not found in any other metalline calx.

The ſaline character of Arſenic appears, firſt, from its being ſoluble in water; ſecondly, from its corroſive quality, which makes it one of the moſt violent poiſons: a quality from which the other metallic ſubſtances are free, when they are not combined with ſome ſaline matter. Regulus of Antimony muſt however be excepted. But then the beſt Chymiſts agree that this ſemi-metal is either nearly of the ſame nature with Arſenic, or contains a portion thereof in its compoſition: beſides, its noxious qualities never diſcover themſelves ſo plainly as when it is combined with ſome acid. Laſtly, Arſenic acts juſt like the vitriolic acid upon nitre; that is, it decompounds that neutral ſalt, by expelling its acid from its alkaline baſis, of which it takes poſſeſſion, and therewith forms a new ſaline compound.

This combination is a ſpecies of ſalt that is perfectly neutral. When the operation is performed in a cloſe veſſel, the ſalt ſhoots into cryſtals in the form of right-angled quadrangular priſms, terminated at each extremity by pyramids that are alſo quadrangular and right-angled; ſome of which however, inſtead of ending in a point, are obtuſe as if truncated. The conſequence is different when the operation is performed in an open veſſel; for then nothing is obtained but an alkaline ſalt impregnated with Arſenic, which cannot be cryſtallized.

The cauſe of this different effect is, that, when the Arſenic is once engaged in the alkaline baſis of the nitre, it can never be ſeparated from it by the utmoſt force of fire, ſo long as it is kept in a cloſe veſſel; whereas, if you expoſe it to the fire without that precaution, it readily ſeparates from it. This property of arſenic was never before obſerved by any Chymiſt, and therefore this our new ſpecies of Neutral arſenical ſalt was abſolutely unknown till lately.

This new ſalt poſſeſſes many ſingular properties, the chief of which are theſe. Firſt, it cannot be decompounded by the intervention of any acid, even the ſtrongeſt acid of vitriol; and this, joined to its property of expelling the nitrous acid from its baſis, ſhews that it has a very great affinity with fixed alkalis.

Secondly, this very ſalt, on which pure acids have no effect, is decompounded with the greateſt eaſe by acids united with metallic ſubſtances. The reaſon of this phenomenon is curious, and furniſhes us with an inſtance of what we advanced concerning double affinities.

If to a reſolution of any metallic ſubſtance whatever, made by any acid whatever, (except that of Mercury by the marine acid, and that of Gold by *aqua regis*), a certain quantity of our New Salt diſſolved in water be added, the metallic ſubſtance is inſtantaneouſly ſeparated from the acid in which it was diſſolved, and falls to the bottom of the liquor.

All metallic precipitates obtained in this manner are found to be a combination of the metal with Arſenic; whence it neceſſarily follows that the new Neutral Salt is by this means decompounded, its arſenical part uniting with the metallic ſubſtance, and its alkaline baſis with the acid in which that ſubſtance was diſſolved.

The affinities of theſe ſeveral bodies muſt be conſidered as operating on this occaſion in the following manner: The acids which tend to decompound the Neutral Salt of Arſenic, by virtue of their affinity with its alkaline baſis, are not able to accompliſh it, becauſe this affinity is powerfully counteracted by that which the Arſenic has with the ſame alkaline baſis, and which is equal or even ſuperior to theirs. But if theſe acids happen to be united with a ſubſtance which naturally has a very great affinity with the arſenical part of the Neutral Salt, then, the two parts of which this Salt conſiſts being drawn different ways by two ſeveral affinities tending to ſeparate them from each other, the Salt will undergo a decompoſition, which could not have been effected without the help of this ſecond affinity. Now, as metallic ſubſtances have a great affinity with Arſenic, it is not ſurpriſing that that the Neutral Salt of Arſenic, which cannot be decompounded by a pure acid, ſhould nevertheleſs yield to an acid combined with a metal. The decompoſition of this Salt, therefore, and the precipitation which of courſe it produces in metallic ſolutions, are brought about by the means of a double affinity; namely, that of the acid with the alkaline baſis of the Neutral Salt, and that of the metal with the arſenical part of that ſalt.

Arſenic has not the ſame effect on ſea-ſalt as on nitre, and cannot expel its acid: a very ſingular phenomenon, for which it is hard to aſſign a reaſon; for the nitrous acid is known to have a greater affinity than the marine acid with alkalis, and even with the baſis of ſea-ſalt itſelf.

Yet Arſenic may be combined with the baſis of ſea-ſalt, and a Neutral Salt thereby obtained, like that which reſults from the decompoſition of nitre by Arſenic: but for that purpoſe a quadrangular nitre muſt be firſt prepared, and Arſenic applied thereto as to common nitre.

The Salt produced by uniting Arſenic with the baſis of ſea-ſalt very much reſembles the Neutral Salt of Arſenic above treated of as well in the figure of its cryſtals as in its ſeveral properties.

Arſenic preſents another ſingular phenomenon, both with the alkali of nitre and with that of ſea-ſalt; which is, that if it be combined with theſe ſalts in a fluid ſtate, it forms with them a ſaline a ſaline compound, quite different from the Neutral Salts of Arſenic which reſult from the decompoſition of nitrous ſalts.

This ſaline compound, which I call *Liver of Arſenic*, takes up a much greater quantity of Arſenic than is neceſſary for the perfect ſaturation of the alkali. It has the appearance of a glue, which is ſo much the thicker the more Arſenic it contains. Its ſmell is diſagreeable; it attracts the moiſture of the air, and does not cryſtallize; it is eaſily decompounded by any acid whatever, which precipitates the Arſenic and unites with the alkali. Laſtly, the effects it produces on metallic ſolutions are different from thoſe of our neutral arſenical ſalts. But the bounds which I have ſet myſelf in this treatiſe will not allow me to be more particular. Such as have the curioſity to inquire further into the ſubject may conſult my Diſſertations on Arſenic, publiſhed among the Memoirs of the Academy of Sciences.

Arſenic is eaſily reduced to a Regulus. It need only be mixed with any matter containing the phlogiſton, and by the help of a moderate heat a true Regulus will ſublime. This Regulus, as was ſaid, is very volatile, and calcines with the greateſt eaſe; which is the reaſon why it cannot be obtained but in ſmall quantities, and alſo why, in order to obtain maſſes of it, ſome have thought of adding thereto ſome metal with which it has a great affinity, ſuch as Copper or Iron; becauſe, by joining with the metal, it is partly fixed and reſtrained from flying off. But it is plain the Regulus obtained by this means is not pure, as it muſt partake conſiderably of the metal employed.

Arſenic readily unites with ſulphur, and riſes with it in a yellow compound, called *Orpiment*.

Sulphur cannot be ſeparated from Arſenic but by the intervention of two bodies only; to wit, a fixed alkali and Mercury.

The property which Mercury poſſeſſes of ſeparating ſulphur from Arſenic is founded on this, that theſe two metallic ſubſtances are incapable of contracting any union; whereas, though moſt of the other metals and ſemi-metals have a greater affinity with ſulphur than Mercury hath, as was ſhewn in treating of the decompoſition of Cinabar, nevertheleſs they are all unable to decompound Orpiment; becauſe ſome of them have as great an affinity with Arſenic as with ſulphur; others have no affinity with either; and laſtly, ſulphur hath as great an affinity with Arſenic as with any of them.

It muſt be obſerved that, if fixed alkalis be employed to purify Arſenic in this manner, no more muſt be uſed than is neceſſary to abſorb the ſulphur or the phlogiſton, of which alſo it is their nature to deprive Arſenic; for otherwiſe, as it has been ſhewn that Arſenic readily unites with alkalis, they would abſorb a conſiderable quantity thereof.

CHAP. X.

Of OIL *in general.*

OIL is an unctuous body, which burns and conſumes with flame and ſmoke, and is not ſoluble in water. It conſiſts of the phlogiſton united with water by means of an acid. There is, moreover, in its compoſition a certain proportion of earth, more or leſs, according to each ſeveral ſort of Oil.

The inflammability of Oil evidently proves that it contains the phlogiſton. That an acid is one of its conſtituent principles many experiments demonſtrate, of which theſe are the chief: If certain Oils be long triturated with an alkaline ſalt, and the alkali afterwards diſſolved in water, cryſtals of a true neutral ſalt will be produced: ſome metals, and particularly Copper, are corroded and ruſted by Oils, juſt as they are by acids: again, acid cryſtals are found in ſome Oils that have been long kept. This acid in Oil ſerves undoubtedly to unite its phlogiſton with its water; becauſe theſe two ſubſtances having no affinity with each other cannot be united without the intervention of ſuch a medium as an acid, which has an affinity with both. As to the exiſtence of water in Oils, it appears plainly when they are decompoſed by repeated diſtillations, eſpecially after mixing them with abſorbent earths. Laſtly, when an Oil is deſtroyed by burning, a certain quantity of earth is conſtantly left behind.

We are very ſure that the abovementioned principles enter into the compoſition of Oils; for they may be obtained from every one of them: but it is not abſolutely certain that they conſiſt of theſe only, and that they do not contain ſome other principle which may eſcape our notice in decompoſing them; for hitherto it doth not appear, by any experiment we can depend on, that Oil was ever produced by combining together the principles here ſpecified: yet ſuch redintegrations are the only means we have of ſatisfying ourſelves that we know all the principles which conſtitute a body.

Oils expoſed to the fire in cloſe veſſels paſs over almoſt wholly from the containing veſſel into any other applied to receive them. There remains, however, a ſmall quantity of black matter, which is extremely fixed, and continues unalterable as long as it hath no communication with the external air, be the force of the fire ever ſo violent. This matter is no other than part of the phlogiſton of the Oil united with its moſt fixed and groſſeſt earth; and this is what we called *Charcoal*, or plainly a *Coal*.

SECTION I.

Of CHARCOAL.

WHEN Oil happens to be united to much earth, as it is in vegetable and animal bodies, it leaves a conſiderable quantity of *Coal* or charred matter.

This Coal, expoſed to the fire in the open air, burns and waſtes, but without blazing like other combuſtible matters: there appears only a ſmall blueiſh flame, but not the leaſt ſmoke. Moſt commonly it only glows and ſparkles, and ſo gradually falls into aſhes, which are nothing but the earth of the body, combined with an alkaline ſalt in burning. This alkaline ſalt may be ſeparated from the earth, by lixiviating the aſhes with water, which diſſolves all the ſalt, and leaves the earth quite pure.

Charcoal is unalterable and indeſtructible by any other body but fire; whence it follows, that when it is not actually kindled and ignited, the moſt powerful agents, ſuch as the acids, though ever ſo ſtrong and concentrated, have not the leaſt effect on it.

The caſe is otherwiſe when it is lighted, that is, when its phlogiſton begins to ſeparate from its earth; for then the pure acid of vitriol being joined therewith, contracts an inſtantaneous union with its phlogiſton, and evaporates in a volatile ſulphureous ſpirit. If the vitriolic acid, inſtead of being appled quite pure, be firſt clogged with ſome baſis, eſpecially an alkaline one, it quits that baſis, enters into a more intimate union with the phlogiſton of the burning Coal, and ſo forms an actual ſulphur, with which the alkali now unites and forms a hepar.

The pure acid of ſea-ſalt hath not been obſerved to act in the leaſt upon Charcoal, eſpecially when it is not on fire.

But when this acid is incorporated with an alkaline or metallic baſis, and combined according to a peculiar proceſs with burning Charcoal, it in like manner quits its baſis, unites with the phlogiſton, and therewith forms a phoſphorus, of which we have already taken notice.

Nor has the pure nitrous acid any effect on a charred Coal, even when ignited: and ſo far is it from being able to kindle a cold one, that when poured on a live one, it extinguiſhes it like water. But when this acid is united with a baſis, it quits it rapidly as ſoon as it touches a burning coal, and ruſhes violently into an union with the phlogiſton thereof. From this union there probably ariſes, as we ſaid before, a kind of ſulphur or phoſphorus, which is ſo inflammable as to be deſtroyed by the fire the very moment it is generated.

The acids of nitre and vitriol act upon Oils; but very differently, according to the quantity of phlegm they contain. If they be weakened with much water, they have no effect at all upon Oils; if they contain little water, or be dephlegmated to a certain degree, they diſſolve them with heat, and with them form compounds of a thick conſiſtence. Acids, thus combined in a conſiderable proportion with Oils, render them ſoluble in water.

SECTION II.

Of SOAP.

ALKALIS alſo have the ſame property. When an Oil is combined with an acid or an alkali in ſuch a manner, that the compound reſulting from their union is ſoluble in water; ſuch a compound may in general be called a *Soap*. Soap itſelf hath the property of rendering fat bodies in ſome meaſure ſoluble in water; on which account it is very uſeful for ſcouring or cleanſing any thing greaſy.

Oily and ſaline ſubſtances, combined together, obſerve the ſame general rules as all other combinations; that is, they mutually communicate the properties belonging to each: thus Oils, which naturally are not ſoluble in water, acquire, by their union with ſaline matters, the property of diſſolving therein; and ſalts loſe, by their conjunction with Oils, part of their natural tendency to incorporate with water; ſo that, while they ſerve to conſtitute ſoap, they do not, as before, attract the moiſture of the air, *&c.* and, in like manner, as they are not inflammable, they conſiderably leſſen the inflammability of the Oils combined with them.

Acid Soaps are decompounded by alkalis, as alkaline Soaps are by acids, according to the general rules of affinities.

The acids of nitre and vitriol, when highly concentrated, diſſolve Oils with ſuch violence as to heat them, make them black, burn them, and even ſet them on fire. How ſea-ſalt affects Oils is not yet ſufficiently aſcertained.

All Oils have the property of diſſolving ſulphur; which is not at all ſurpriſing, ſeeing each of its component principles hath an affinity with Oil.

It is alſo a property common to all Oils to become more fluid, ſubtile, light, and limpid, the oftener they are diſtilled. On the contrary, by being incorporated with ſaline ſubſtances they acquire a greater conſiſtence, and ſometimes form compounds that are moſt ſolid.

CHAP. XI.

Of the ſeveral Sorts of OILS.

OILS are diſtinguiſhed by the ſubſtances from which they are drawn: and as Oils are extracted from minerals, from vegetables, and from animals, there are of courſe Mineral, Vegetable, and Animal Oils.

SECTION I.

Of MINERAL OILS.

In the bowels of the earth we find but one ſort of Oil, called *Petroleum:* its ſmell is ſtrong and not diſagreeable, and its colour ſometimes more ſometimes leſs yellow. There are certain mineral ſubſtances which yield by diſtillation a great deal of Oil very like Petroleum. This ſort of ſubſtance is called a *Bitumen*, and is, indeed, nothing but an Oil rendered conſiſtent and ſolid by being combined with an acid; as appears from hence, that by uniting Petroleum with the acid of vitriol we can produce an artificial Bitumen very like the native.

SECTION II.

Of VEGETABLE OILS.

VEGETABLE ſubſtances yield a very great quantity and variety of oils: for there is not a plant, or part of a plant, that does not contain one or more ſorts thereof, generally peculiar to itſelf, and different from all others.

By expreſſion only, that is, by bruiſing and ſqueezing vegetable ſubſtances, particularly certain fruits and ſeeds, a ſort of oil is obtained which has ſcarce any ſmell or taſte. Oils of this ſort are very mild and unctuous; and, becauſe in this reſpect they reſemble animal fat more than the reſt do, they are called *Fat Oils*.

Theſe Oils, being expoſed to the air for ſome time, ſooner or latter grow thick, acquire an acrid taſte, and a ſtrong diſagreeable ſmell. Some of them congeal with the ſmalleſt degree of cold. This ſort of Oil is well adapted to diſſolve thoſe preparations of Lead called Litharge and Minium, with which they form a thick tenacious ſubſtance, that is uſed for the baſis of almoſt all plaſters. They alſo diſſolve Lead in its metalline form; but not ſo eaſily as the ſorts of calx abovementioned; probably becauſe its body is not ſo much opened, nor its parts ſo divided.

By expreſſion alone we alſo procure from certain vegetable ſubſtances another ſort of Oil, which is thin, limpid, volatile, of a pungent taſte, and retains the ſmell of the vegetable that yielded it; on which account it is called an *Eſſential Oil*. Of this there are ſeveral ſorts, differing from one another, like the Fat Oils, according to the ſubjects from which they are obtained.

We muſt obſerve, that it is very difficult, or rather in moſt caſes impoſſible, to force from the greateſt part of vegetables, by expreſſion only, all the eſſential Oil they contain. For this purpoſe therefore recourſe muſt be had to fire: a gentle heat, not exceeding that of boiling water, will extract all the eſſential Oils of vegetables; and this is the moſt uſual and moſt convenient way of procuring them.

The fat Oils cannot be obtained by the ſame method: theſe being much leſs volatile than the eſſential Oils, require a much greater degree of heat to raiſe them; which nevertheleſs they cannot bear without being much ſpoiled and entirely changed in their nature, as ſhall preſently be ſhewn. All

Oils, therefore, which riſe with the heat of boiling water, and ſuch alone, ſhould be called Eſſential Oils.

Eſſential Oils, in a longer or ſhorter time, according to the nature of each, loſe the fragrant ſmell they had when newly diſtilled, and acquire another, which is ſtrong, rancid, and much leſs agreeable: they alſo loſe their tenuity, becoming thick and viſcid; and in this ſtate they greatly reſemble thoſe ſubſtances abounding in Oil which flow from certain trees, and which are called *Balſams* or *Reſins*, according as they are leſs or more conſiſtent.

Balſams and Reſins are not ſoluble in water. But there are other Oily compounds which likewiſe run from trees; and, though not unlike Reſins, are however ſoluble in water. Theſe are called *Gums;* and their property of diſſolving in water ariſes from their containing more water and more ſalt than Reſins have; or at leaſt their ſaline parts are leſs clogged and more diſengaged.

Balſams and Reſins diſtilled with the heat of boiling water yield great quantities of a limpid, ſubtile, odoriferous, and, in one word, eſſential Oil. In the ſtill there remains a ſubſtance thicker and more conſiſtent than the Balſam or Reſin was before diſtillation. The ſame thing happens to eſſential Oils which by length of time have acquired a conſiſtence and are grown reſinous. If they be rediſtilled, they recover their former tenuity, leaving behind them a remainder thicker and more reſinous than they themſelves were. This ſecond diſtillation is called the *Rectification* of an Oil.

It muſt be obſerved, that an eſſential Oil, combined with an acid ſtrong enough to diſſolve it, immediately becomes as thick and reſinous, in conſequence of this union, as if it had been long expoſed to the air: which proves the conſiſtence an Oil acquires by long keeping to be owing to this, that its lighteſt and leſs acid parts being evaporated, the proportion of its acid to the remainder is ſo increaſed, that it produces therein the ſame change, as an additional acid mixed with the Oil would have wrought before the evaporation.

This alſo ſhews us, that Balſams and Reſins are only eſſential Oils combined with a great proportion of acid, and thereby thickened.

If vegetable ſubſtances, from which no more eſſential Oil can be drawn by the heat of boiling water, be expoſed to a ſtronger heat, they yield an additional quantity of Oil; but it is thicker and heavier than the eſſential Oil. Theſe Oils are black, and have a very diſagreeable burnt ſmell, which hath made them be called *Fetid* or *Empyreumatic* Oils. They are moreover very acrid.

It muſt be obſerved, that, if a vegetable ſubſtance be expoſed to a degree of heat greater than that of boiling water, before the fat or the eſſential Oil is extracted from it, an empyreumatic Oil only will then be obtained; becauſe both the fat and eſſential Oils, when expoſed to the force of fire, are thereby burnt, rendered acrid, acquire a ſmell of the fire, and, in a word, become truly empyreumatic. There is ground to think, that an empyreumatic Oil is nothing elſe but an eſſential or fat Oil burnt and ſpoiled by the fire, and that no other Oil beſides theſe two exiſts naturally in vegetables.

Empyreumatic Oils, diſtilled and rectified ſeveral times by a gentle heat, acquire by every diſtillation a greater degree of tenuity, lightneſs, and limpidity. By this means alſo they loſe ſomething of their diſagreeable odour; ſo that they gradually come nearer and nearer to the nature of eſſential Oils: and if the rectifications be often enough repeated, ten or twelve times for inſtance, they become perfectly like thoſe Oils; except that their ſmell will never be ſo agreeable, nor like that of the ſubſtances from which they were obtained.

Fat Oils may alſo be brought by the ſame means to reſemble eſſential Oils: but neither eſſential nor empyreumatic Oils are capable of acquiring the properties of fat Oils.

SECTION III.

Of ANIMAL OILS.

DISTILLATION procures us conſiderable quantities of Oil from all the parts of animal bodies, and eſpecially from their fat. This Oil at firſt is not very fluid, and is extremely fetid: but by many rectifications it gradually acquires a great degree of clearneſs and tenuity, and at the ſame time loſes much of its diſagreeable odour. Animal Oils, thus rendered thin and fluid by a great number of rectifications, have the reputation of being an excellent medicine, and a ſpecific in the epilepſy.

CHAP.

C H A P. XII.

Of FERMENTATION *in general.*

BY Fermentation is meant an inteſtine motion, which, ariſing ſpontaneouſly among the inſenſible parts of a body, produces a new diſpoſition and a different combination of thoſe parts.

To excite a Fermentation in a mixt body, it is neceſſary, firſt, that there be in the compoſition of that mixt a certain proportion of watery, ſaline, oily, and earthy parts: but this proportion is not yet ſufficiently aſcertained. Secondly, it is requiſite that the body to be fermented be placed in a certain degree of temperate heat: for much cold obſtructs fermentation; and too much heat decompoſes bodies. Laſtly, the concurrence of the air is alſo neceſſary to fermentation.

All vegetable and animal ſubſtances are ſuſceptible of Fermentation, becauſe all of them contain in a due proportion the principles above ſpecified. However, many of them want the proper quantity of water, and cannot ferment while they remain in ſuch a ſtate of dryneſs. But it is eaſy to ſupply that defect, and ſo render them very apt to ferment.

With reſpect to minerals properly ſo called, (that is, excluding ſuch vegetable and animal ſubſtances as may have lain long buried in the earth), they are not ſubject to any Fermentation; at leaſt, that our ſenſes can perceive.

There are three ſorts of Fermentation, diſtinguiſhed from one another by their ſeveral productions. The firſt produces wines and ſpirituous liquors; for which reaſon it is called the *Vinous* or *Spirituous Fermentation:* the reſult of the ſecond is an acid liquor; and therefore it is called the *Acetous Fermentation:* and the third generates an alkaline ſalt; which, however, differs from the alkaline ſalts hitherto treated of, in this reſpect chiefly, that, inſtead of being fixed, it is extremely volatile: this laſt ſort takes the name of the *Putrid* or *Putrefactive Fermentation.* We ſhall now conſider theſe three ſorts of Fermentation and their effects a little more particularly.

Theſe three ſorts of Fermentation may take place ſucceſſively in the ſame ſubject; which proves them to be only three different degrees of fermentation, all proceeding from one and the ſame cauſe, rather than three diſtinct fermentations. Theſe degrees of fermentation always follow the order in which we have here placed them.

CHAP. XIII.

Of the SPIRITUOUS FERMENTATION.

THE juices of almoſt all fruits, all ſaccharine vegetable matters, all farinaceous ſeeds and grains of every kind, being diluted with a ſufficient quantity of water, are proper ſubjects of Spirituous Fermentation. If ſuch liquors be expoſed, in veſſels ſlightly ſtopped, to a moderate degree of heat, they begin in ſome time to grow turbid; there ariſes inſenſibly a ſmall commotion among their parts, attended with a hiſſing noiſe; this by little and little increaſes, till the groſſer parts appear, like little ſeeds or grains, moving to and fro, agitated among themſelves, and thrown up to the ſurface. At the ſame time ſome air bubbles riſe, and the liquor acquires a pungent, penetrating ſmell, occaſioned by the very ſubtile vapours which exhale from it.

Theſe vapours have never yet been collected, in order to examine their nature; and they are known only by their noxious effects. They are ſo actively pernicious, that if a man comes raſhly into a cloſe place, where large quantities of liquors are fermenting, he ſuddenly drops down and expires, as if he were knocked on the head.

When theſe ſeveral phenomena begin to go off, it is proper to ſtop the fermentation, if a very ſpirituous liquor be required: for if it be ſuffered to continue longer, the liquor will become acid, and from thence proceed to its laſt ſtage, that is, to putrefaction. This is done by ſtopping the containing veſſels very cloſe, and removing them into a cooler place. Then the impurities precipitate, and ſettling at the bottom leave the liquor clear and tranſparent: and now the palate diſcovers that the ſweet ſaccharine taſte it had before fermentation is changed to an agreeable pungency, which is not acid.

Liquors thus fermented are in general called *Wines:* for though in common life that word properly ſignifies the fermented juice of grapes only, and particular names are given to the fermented juices of other vegetable ſubſtances; as that obtained from Apples is called *Cyder*; that made from malt is called *Beer*: yet in Chymiſtry it is of uſe to have one general term denoting every liquor that has undergone this firſt degree of fermentation.

By diſtillation we draw from Wine an inflammable liquor, of a yellowiſh white colour, light, and of a penetrating, pleaſant ſmell. This liquor is the truly ſpirituous part of the wine, and the product of fermentation. That which comes off in the firſt diſtillation is commonly loaded with much phlegm and ſome oily parts, from which it may be afterwards freed. In this ſtate it goes by the name of *Brandy*; but when freed from theſe heterogeneous matters by repeated diſtillations, it becomes ſtill clearer, lighter, more fragrant, and much more inflammable, and then is called *Spirit of Wine*, and *Rectified Spirit of Wine*, or an *Ardent Spirit*, if conſiderably purified. The properties which diſtinguiſh an Ardent Spirit from all other ſubſtances are its being inflammable; its burning and conſuming entirely, without the leaſt appearance of ſmoke or fuliginoſity; its containing no particles reducible to a coal; and its being perfectly miſcible with water. Ardent Spirits are lighter and more volatile than any of the principles of the mixts from which they were produced, and conſequently more ſo than the phlegm, the acid, and the oil of which they themſelves conſiſt. This ariſes from a particular diſpoſition of theſe principles, which are in a ſingular manner attenuated by fermentation, and thereby rendered more ſuſceptible of expanſion and rarefaction.

Ardent ſpirits are ſuppoſed to be the natural ſolvents of oils and oily matters. But it is very remarkable that they diſſolve eſſential oils only, without touching the fat of animals, or the fat oils obtained from vegetables by expreſſion; yet when theſe oils have once undergone the action of fire, they become ſoluble in ſpirit of wine, and even acquire a new degree of ſolubility every time they are diſtilled. It is not ſo with eſſential oils, which can never be rendered more ſoluble in ardent ſpirits than they are at firſt; and are ſo far from acquiring a new degree of ſolubility every time they are diſtilled, that on the contrary they even in ſome meaſure loſe that property by repeated rectifications.

I have taken ſome pains to find out the cauſes of theſe ſingular effects, and the reſult of my inquiries is publiſhed among the Memoirs of the Academy of Sciences for the year 1745. I therein conſider ardent ſpirits as conſiſting of an oil, or at leaſt a phlogiſton, mixed with a portion of water,

ter, in which it is rendered ſoluble by means of an acid. This being laid down, I ſhew that the inability of ſpirit of wine to diſſolve ſome oils muſt be imputed to its aqueous part, in which oils are not naturally ſoluble without the intervention of a ſalt: and that the power which this ſpirit exerts in diſſolving other oils with eaſe, ſuch as eſſential oils, muſt in all probability be owing to this, that in theſe oils it meets with the neceſſary ſaline medium, that is, with an acid, which numberleſs experiments ſhew they actually contain.

On the other hand, I there prove, that the acid in eſſential oils is ſuperabundant, and in ſome ſort foreign to their nature, or that it is but ſlightly connected with them, and in part deſerts them every time they are diſtilled; which renders them leſs ſoluble after every new rectification: whereas, on the contrary, the fat expreſſed oils in their natural ſtate give not the leaſt ſign of acidity; but the action of fire upon them diſcovers an acid which was not perceivable before. Hence I conjecture, that theſe oils contain no more acid than is juſt neceſſary to conſtitute them oils; that this acid is intimately blended with their other component parts; that it is ſo ſheathed and entangled by theſe parts as to be incapable of exerting any of its properties; and that on this account theſe oils in their natural ſtate are not ſoluble in ſpirit of wine: but that the diſpoſition of their parts being gradually changed by the fire, and their acid, being by that means ſet more and more at liberty, at length recovers its properties, and particularly that of rendering the oily parts ſoluble in an aqueous menſtruum: and hence it follows, that the fat oils become ſo much the more ſoluble in ſpirit of wine the oftener they are expoſed to the action of fire.

Spirit of wine doth not diſſolve fixed alkalis; or at leaſt it takes up but a very ſmall quantity thereof; and hence ardent ſpirits may be freed from much of their phlegm by means of theſe ſalts thoroughly dried: for as they ſtrongly imbibe moiſture, and have even a greater affinity than ardent ſpirits with water, if a fixed alkali, well exſiccated, be mixed with ſpirit of wine that is not perfectly dephlegmated, the alkali immediately attracts its ſuperfluous moiſture, and is thereby reſolved into a liquor, which, on account of its gravity, deſcends to the bottom of the veſſel. The ſpirit of wine, which ſwims at top, is by this means as much dephlegmated, and as dry, as if it had been rectified by ſeveral diſtillations. As it takes up ſome alkaline particles in this operation, it is thereby qualified to diſſolve oily matters with the greater facility.

cility. When rectified in this manner, it is called *Alcoholized Spirit of Wine.*

Yet ſpirit of wine, even when rectified to an alcohol, is not capable of diſſolving all oily matters. Thoſe named Gums will by no means enter into any ſort of union therewith; but it readily diſſolves moſt of thoſe which are known by the appellation of Reſins. When it has diſſolved a certain proportion of reſinous particles it acquires a greater conſiſtence, and forms what is called a *Spirit Varniſh*, or a *Drying Varniſh*, becauſe it ſoon dries. This Varniſh is ſubject to be damaged by water. Many ſorts thereof are prepared, differing from each other according to the different reſins employed, or the proportions in which they are uſed. Moſt of theſe Varniſhes are tranſparent and colourleſs.

Such bitumens or reſins, as ſpirit of wine will not touch, are diſſolved in oils by means of fire, and then form another kind of Varniſh, which water does not hurt. Theſe Varniſhes are uſually coloured, and require much longer time to dry than the Spirit Varniſhes: they are called *Oil Varniſhes.*

Spirit of wine hath a much greater affinity with water than with oily matters: and therefore if a ſolution of any oil or reſin in ſpirit of wine be mixed with water, the liquor immediately grows turbid, and acquires a whitiſh milky colour, owing entirely to the oily parts being ſeparated from the ſpirituous menſtruum by the acceſſion of water, and too finely divided to appear in their natural form. But if the liquor ſtand ſome time quiet, ſeveral of theſe particles unite together, and gradually acquire a bulk ſufficient to render them very perceptible to the eye.

Acids have an affinity with ſpirit of wine, and may be combined with it. By this union they loſe moſt of their acidity, and on that account are ſaid to be *Dulcified.* But as theſe combinations of acids, eſpecially of the vitriolic acid, with ſpirit of wine furniſh ſome new productions of very ſingular properties, and as an examination thereof may throw much light on the nature of ardent ſpirits, it will not be amiſs to take notice of them in this place, and conſider each of them particularly.

One part of highly concentrated oil of vitriol being mixed with four parts of well dephlegmated ſpirit of wine, there ariſes immediately a conſiderable ebullition and effervеſcence, attended with great heat, and abundance of vapours, which ſmell pleaſantly, but are hurtful to the lungs. At the ſame time is heard a hiſſing like that produced by a piece of red-hot iron plunged into water. Indeed it is proper to mix the liquors very gradually; for otherwiſe the veſſels in which the operation is performed will be in great danger of breaking.

If the two liquors thus mixed be diſtilled with a very gentle heat, there riſes firſt a ſpirit of wine of a moſt penetrating and grateful odour: when about half thereof is come over, what follows has a quicker and more ſulphureous ſmell, and is alſo more loaded with phlegm. When the liquor begins to boil a little, there comes off a phlegm which ſmells very ſtrong of ſulphur, and grows gradually more acid. On this phlegm floats a ſmall quantity of a very light and very limpid oil. In the ſtill there remains a thick blackiſh ſubſtance, ſomewhat like a reſin or bitumen. From this ſubſtance may be ſeparated a good deal of a vitriolic but ſulphureous acid. When that is extracted, there remains a black maſs like a charred coal, which being put into a crucible, and expoſed to a violent heat, leaves a ſmall portion of earth, very fixed, and even vitrifiable.

By rectifying the ardent ſpirit, which came over in diſtilling the above-mentioned mixture, a very ſingular liquor is obtained, which differs eſſentially both from oils and from ardent ſpirits, though in certain reſpects it reſembles them both. This liquor is known in Chymiſtry by the name of *Æther*, and its chief properties are as follow.

Æther is lighter, more volatile, and more inflammable, than the moſt highly rectified ſpirit of wine. It quickly flies off when expoſed to the air, and ſuddenly catches fire when any flame approaches it. It burns like ſpirit of wine without the leaſt ſmoke, and conſumes entirely without leaving the ſmalleſt appearance of a coal or of aſhes. It diſſolves oils and oily matters with great eaſe and rapidity. Theſe properties it has in common with an ardent ſpirit. But it reſembles an oil in that it is not miſcible with water; and this makes it eſſentially different from ſpirit of wine, the nature of which is to be miſcible with all aqueous liquors.

Another very ſingular property of Æther is its great affinity with gold, exceeding even that of *aqua regis*. It does not indeed diſſolve gold when in a maſs, and in its metalline form; but if a ſmall quantity of Æther be added to a ſolution of gold in *aqua regis*, and the whole ſhaken together, the gold ſeparates from the *aqua regis*, joins the Æther, and remains diſſolved therein.

The reaſon of all the phenomena above-mentioned, reſulting from the mixture of ſpirit of wine with oil of vitriol, is founded on the great affinity between this acid and water. For if the vitriolic acid be weak, and as it were overdoſed with watery parts, neither oil nor Æther can be obtained by means thereof: but when highly concentrated, it attracts the aqueous parts very powerfully; and therefore, being mixed with ſpirit of wine, lays hold of moſt of the water contained in it, and even robs it of ſome portion of that which is eſſential to its nature, and neceſſary to conſtitute it ſpirit of wine: whence it comes to paſs, that a certain quantity of the oily particles in its compoſition being ſeparated from the watery particles, and ſo brought nearer to each other, they unite and aſſume their natural form; and thus the oil that ſwims at top of the ſulphureous phlegm is produced.

The vitriolic acid moreover thickens and even burns ſome of this oil; and hence comes the bituminous reſiduum left at the bottom of the ſtill, which looks like the reſult of a vitriolic acid combined with common oil. Laſtly, the vitriolic acid becomes ſulphureous, as it always doth when united with oily matters, and alſo very aqueous, on account of the quantity of phlegm which it attracts from the ſpirit of wine.

Æther may be conſidered as a ſpirit of wine exceedingly dephlegmated, even to ſuch a degree that its nature is thereby changed; ſo that the few aqueous particles left in it are not ſufficient to diſſolve the oily particles and keep them aſunder; which therefore being now much nearer to one another than in common ſpirit of wine, the liquor hath loſt its property of being miſcible with water.

Spirit of nitre well dephlegmated, and combined with ſpirit of wine, preſents likewiſe ſome very ſingular appearances.

Firſt, in the very inſtant of its mixture with ſpirit of wine, it produces a greater and more violent effervеſcence than the vitriolic acid occaſions.

Secondly, this mixture, without the help of diſtillation, and only by ſtopping the bottle in which the liquors are contained, affords a ſort of Æther, produced probably by the vapours which aſcend from, and ſwim at top of the mixture. This is a very ſingular liquor. Dr. Navier was the firſt that took notice of it, and gave a deſcription thereof, which may be ſeen in the Memoirs of the Academy of Sciences.

Thirdly, ſome authors pretend that, by diſtilling the mixture under conſideration, an oil is obtained greatly reſembling that which, as we obſerved above, riſes from ſpirit of wine combined with the vitriolic acid: others again deny this. For my part, I believe the thing depends on the different concentration of the ſpirit of nitre, as well as on the quality of the ſpirit of wine, which is ſometimes more ſometimes leſs oily.

Fourthly, the two liquors we are ſpeaking of, being intimately mixed by diſtillation, form a liquor ſlightly acid, uſed in medicine, and known by the name of *Sweet* or *Dulcified Spirit of Nitre:* a very proper name, ſeeing the nitrous acid, by uniting with the ſpirit of wine, actually loſes almoſt all its acidity and corroſive quality.

Fifthly and laſtly, when the diſtillation is finiſhed, there remains in the bottom of the veſſel a thick blackiſh ſubſtance, nearly reſembling that which is found after diſtilling oil of vitriol and ſpirit of wine.

Spirit of ſalt hath likewiſe been combined with ſpirit of wine; but it does not unite therewith ſo eaſily or ſo intimately as the two acids above-mentioned. To mix them thoroughly, the ſpirit of ſalt muſt be highly concentrated, and ſmoking, and moreover the aſſiſtance of the ſtill muſt be called in. Some authors pretend that from this mixture alſo a ſmall quantity of oil may be obtained; which probably happens when the liquors have the qualities above-ſpecified. The marine acid likewiſe, by uniting with ſpirit of wine, loſes moſt of its acidity; on which account it is in like manner called *Sweet* or *Dulcified Spirit of Salt.* A thick reſiduum is alſo found here after diſtillation.

CHAP. XIV.

Of the ACETOUS FERMENTATION.

BESIDES an ardent ſpirit, wine affords a great deal of water, oil, earth, and a ſort of acid which ſhall be conſidered preſently. When the ſpirituous part is ſeparated from theſe other matters, they undergo no further change. But if all the conſtituent parts of wine remain combined together, then, after ſome time, ſhorter or longer as the degree of heat in which the wine ſtands is greater or leſs, the fermentation begins afreſh, or rather arrives at its ſecond ſtage. The liquor once more grows turbid, a new inteſtine motion ariſes, and, after ſome days, it is found changed into an acid; which, however, is very different from thoſe hitherto treated of. The liquor then takes the name of *Vinegar*. The acetous fermentation differs from the ſpirituous, not only in its effect, but alſo in ſeveral of its concomitant circumſtances. Moderate motion is of ſervice to this, whereas it obſtructs the ſpirituous; and it is attended with much more warmth than the ſpirituous. The vapours it produces are not noxious, like thoſe of fermenting wine. Laſtly, Vinegar depoſites no tartar, even when the wine employed in this operation is quite new, and hath not had time to diſcharge its tartar: inſtead of tartar, Vinegar depoſites a viſcid matter which is very apt to putrify.

It muſt be obſerved, that wine is not the only ſubſtance that is ſuſceptible of the acetous fermentation: for ſeveral vegetable and even animal matters, which are not ſubject to the ſpirituous fermentation, turn ſour before they putrify. But as vinous liquors poſſeſs in a very eminent degree the property of being ſuſceptible of the acetous fermentation, and likewiſe of producing the ſtrongeſt acids that can reſult from ſuch fermentation, their acid ſhall be more particularly conſidered in this place.

SECTION I.

Of VINEGAR.

IF wine, which has gone through this ſecond ſtage of fermentation, be diſtilled, inſtead of an ardent ſpirit, only an acid liquor is obtained, which is called *Diſtilled Vinegar*.

This acid has the ſame properties as the mineral acids of which we have already treated; that is, it unites with alkaline ſorts, abſorbent earths, and metallic ſubſtances, and therewith forms neutral ſaline combinations.

Its affinity with theſe ſubſtances obſerves the ſame order as that obſerved by the mineral acids with regard to the ſame ſubſtances; but in general it is weaker; that is, any mineral acid is capable of expelling the acid of Vinegar out of all matters with which it is united.

Vinegar hath likewiſe a greater affinity than ſulphur with alkalis: whence it follows, that it is capable of decompounding that combination of ſulphur with an alkali called Liver of Sulphur, and of precipitating the ſulphur it contains.

The acid of Vinegar is always clogged with a certain proportion of oily parts, which greatly weaken it, and deprive it of much of its activity; and for this reaſon it is not near ſo ſtrong as the mineral acids, which are not entangled with any oil. By diſtillation, indeed, it may be freed from this oil, and at the ſame time from the great quantity of water which in a manner ſuffocates it, and by that means may be brought much nearer to the nature of the mineral acids: but this attempt hath not yet been proſecuted with the aſſiduity it deſerves. Beſides diſtillation, there is another way of freeing Vinegar from a good deal of its phlegm; and that is, by expoſing it to a hard froſt, which readily congeals the watery part into ice, while the acid retains its fluidity.

Vinegar, ſaturated with a fixed alkali, forms a neutral oily ſalt, of a dark colour, which is ſemi-volatile, melts with a very gentle heat, flames when thrown upon burning coals, and diſſolves in ſpirit of wine, of which, however, it requires ſix parts to complete the ſolution. This ſolution being evaporated to dryneſs leaves a matter in the form of leaves lying on each other; on which account it hath obtained the name of *Terra Foliata.* The ſame foliated matter will be obtained, though the ſalt be not previouſly diſſolved in ſpirit of wine; but not ſo readily. This ſalt is alſo called *Regenerated Tartar.* Under the head of Tartar we ſhall ſee the reaſon of theſe different appellations. Regenerated Tartar is alſo in ſome degree capable of cryſtallizing: for this purpoſe a ſolution thereof in water muſt be ſlowly evaporated to the conſiſtence of a ſyrup, and then ſuffered to ſtand quiet in a cool place; by which means it will ſhoot into cluſters of cryſtals, lying one upon another, not unlike the feathers on a quill.

With Vinegar and ſeveral abſorbent earths, ſuch as calcined pearls, coral, ſhells of fiſh, *&c.* are alſo formed neutral ſaline compounds, each of which takes the name of the particular earth employed in its compoſition.

Vinegar perfectly diſſolves Lead, and converts it to a neutral metallic ſalt, which ſhoots into cryſtals, and has a ſweet ſaccharine taſte. This compound is called *Sugar of Lead*, or *Sal Saturni.*

If Lead be expoſed to the bare vapour of Vinegar, it will be thereby corroded, calcined, and converted into a white matter much uſed in painting, and known by the name of *Ceruſe;* or, when it is finer than ordinary, *White Lead.*

Vinegar corrodes Copper likewiſe, and converts it into a beautiful green ruſt, which alſo is uſed in painting, and diſtinguiſhed by the name of *Verdegris.* However, Vinegar is not commonly employed to make Verdegris: for this purpoſe they uſe wine, or the rape of wine, from which fire extricates an acid analogous to that of Vinegar.

In treating of the ſeveral ſubſtances which conſtitute wine, we mentioned an acid matter, but did not then enter into a particular examination thereof; becauſe as that matter greatly reſembles the acid of Vinegar, we thought it more proper to defer the conſideration of its properties till we had treated of the acetous fermentation, and its effects.

SECTION II.

Of TARTAR.

THIS ſubſtance is a ſaline compound, conſiſting of earthy, oily, and eſpecially acid parts. It is found in the form of cruſts, adhering to the inner ſides of veſſels in which wines have ſtood for ſome time, particularly acid wines, ſuch as thoſe of Germany.

Tartar derives its origin from the ſuperabundant quantity of acid contained in the juice of the grape. This ſuperfluous acid, being more than is requiſite to conſtitute the ardent ſpirit, unites with ſome of the oil and earth contained in the fermented liquor, and forms a kind of ſalt; which for ſome time continues ſuſpended in that liquor, but, when the wine ſtands undiſturbed in a cool place, is depoſited, as hath been ſaid, on the ſides of the caſk.

Tartar in this ſtate contains many earthy parts, which are ſuperfluous, and foreign to its nature. From theſe it may be freed by boiling it repeatedly with a ſort of earth found in the neighbourhood of Montpelier, as may be ſeen in the Memoirs of the Academy of Sciences.

When it is purified, there appears on the ſurface of the liquor a ſort of white cryſtalline pellicle, which is ſkimmed off as it forms. This matter is called *Cream of Tartar.* The ſame liquor which produces this Cream, and in which the purified Tartar is diſſolved, being ſet to cool, yields a great number of white ſemi-tranſparent cryſtals, which are called *Cryſtals of Tartar.* The Cream and the Cryſtals of Tartar are therefore no other than purified Tartar, and differ from each other in their form only.

Though the Cryſtals of Tartar have every appearance of a neutral ſalt, yet they are far from being ſuch; for they have all the properties of a true acid, which ſcarce differs from that of vinegar, except that it contains leſs water, and more earth and oil; to which it owes its ſolid form, as well as its property of not being ſoluble in water without much difficulty: for a very great quantity of water is requiſite to keep the Cryſtals of Tartar in ſolution; and it muſt moreover be boiling hot; otherwiſe as ſoon as it cools moſt of the Tartar diſſolved in it ſeparates from the liquor, and falls to the bottom in the form of a white powder.

Tartar is decompoſed by calcination in the open fire. All its oily parts are conſumed or diſſipated in ſmoke, together with moſt of its acid. The other part of its acid, uniting intimately with its earth, forms a very ſtrong and very pure fixed alkali, called *Salt of Tartar.*

It will be ſhewn in its proper place, that almoſt every vegetable matter, as well as Tartar, leaves a fixed alkali in its aſhes: yet Tartar has theſe peculiar properties; firſt, it aſſumes an alkaline character even when burnt or calcined in cloſe veſſels, whereas other ſubſtances acquire it only by being burnt in the open air; ſecondly, the alkali of Tartar is ſtronger and more ſaline than almoſt any that is obtained from other matters.

This alkali, when thoroughly calcined, powerfully attracts the moiſture of the air, and melts into an unctuous alkaline liquor, improperly called *Oil of Tartar per deliquium.* This is the alkali generally uſed in making the *Terra Foliata,* mentioned under the head of Vinegar; for which reaſon this combination is called *Terra Foliata Tartari;* a name ſuitable enough. But the ſame cannot be ſaid of the other name, *Regenerated Tartar,* which is alſo given it. It is true, that on this occaſion an oily acid is reſtored to the earth of the Tartar, analagous to that of which the fire had deprived it: but the compound thence reſulting is a neutral ſalt which very readily diſſolves in water; whereas Tartar is manifeſtly acid, and not ſoluble, or at leaſt hardly ſoluble, in water.

Cryſtals of Tartar combined with alkali of Tartar produce a great effervеſcence while they are mixing, as all acids uſually do; and if the combination be brought exactly up to the point of ſaturation, a perfectly neutral ſalt is formed, which ſhoots into cryſtals, and eaſily diſſolves in water; and this hath procured it the name of *Soluble Tartar.* It is alſo called the *Vegetable Salt,* as being obtained from vegetables only; and again, *Tartariſed Tartar,* becauſe it conſiſts of the acid and the alkali of Tartar combined together.

Cryſtals of Tartar combined with alkalis procured from the aſhes of maritime plants, ſuch as Soda, which alkalis reſemble the baſis of ſea-ſalt, form likewiſe a neutral ſalt, which cryſtallizes well, and diſſolves eaſily in water. This ſalt is another ſort of ſoluble Tartar. It is called *Saignette*'s *Salt*, from the inventor's name.

Both the Vegetable Salt and Saignette's Salt are gently purgative ſoaps, and much uſed in Medicine.

Tartar likewiſe diſſolves the abſorbent earths, as lime, chalk, *&c.* and with them forms neutral ſalts which are ſoluble in water *. It even attacks metallic bodies, and when combined with them becomes ſoluble. A ſoluble Tartar for medical uſe is prepared with Cryſtals of Tartar and Iron: the metallic ſalt thereby produced hath the name of *Chalybeated Soluble Tartar*. This ſalt attracts the moiſture of the air, and is one of thoſe which do not cryſtallize.

Cryſtallized Tartar acts alſo upon ſeveral other metallic ſubſtances: for inſtance, it diſſolves the Regulus, Liver, and Glaſs of Antimony, and thence acquires an emetic quality: it is then called *Stibiated* or *Emetic Tartar*. It likewiſe diſſolves Lead, and therewith forms a ſalt which, in the figure of its cryſtals, reſembles Tartariſed Tartar.

It is very eatraordinary that Tartar, which of itſelf is not ſoluble in water, ſhould be ſoluble therein when become a neutral ſalt by uniting either with alkalis or with abſorbent earths, or even with metals. With reſpect to alkalis, indeed, it may be urged, that, having themſelves a great affinity with water, they communicate to Tartar ſome of that facility with which they naturally unite therewith: but the ſame cannot be alledged concerning abſorbent earths, and metallic ſubſtances, which water diſſolves not at all, or at leaſt with great difficulty, and in ſmall quantity. This effect, therefore, muſt be attributed wholly to ſome change in the diſpoſition of its parts which is to us unknown.

All the Soluble Tartars are eaſily decompounded by expoſing them to a certain degree of heat. In diſtillation they yield the ſame principles which are obtained from Tartar; and what remains fixed in the fire, after they are thoroughly burnt, is a compound of the alkali which Tartar naturally produces, and of the alkaline or metallic ſubſtance with which it was converted into a neutral ſalt.

As Cryſtal of Tartar is the weakeſt of all acids, on account of the oily and earthy matters with which it is combined, Soluble Tartars are decompounded by all the acids; by any of which cryſtal of Tartar may be ſeparated from the ſubſtance that ſerves it for a baſis and renders it a neutral ſalt.

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* See Mr. Duhamel's Eſſays on this ſubject in the Memoirs of the Academy of Sciences.

The other acids which are procured from vegetables, and even thoſe which are obtainable from ſome animal ſubſtances, may all be referred to and compared with either Vinegar or Tartar, according to the quantities of oil or earth with which they are combined.

After all, theſe acids have not yet been thoroughly examined. There is great reaſon to think that they are no other than the mineral acids, which, in paſſing through the bodies of vegetables, and even of animals, undergo a conſiderable change, eſpecially by contracting an union with oily matters. For, as we ſaid before in treating of Vinegar, by freeing them from their oil they are brought very near to the nature of mineral acids; and ſo likewiſe the mineral acids acquire many of the properties of vegetable acids by being combined with oils.

CHAP. XV.

Of the PUTRID FERMENTATION, *or* PUTREFACTION.

EVERY body which hath gone through the two ſtages of fermentation above deſcribed, that is, the ſpirituous and the acetous fermentation, being left to itſelf in a due degree of warmth, which varies according to the ſubject, advances to the laſt ſtage of fermentation; that is, to putrefaction.

It is proper to obſerve, before we go any further, that the converſe of this propoſition is not true; that is, it is not neceſſary that a body ſhould ſucceſſively paſs through the ſpirituous and the acetous fermentation, before it can arrive at the putrid; but that, as certain ſubſtances fall into the acetous without having gone through the ſpirituous fermentation, ſo others begin to putrify without having undergone either the ſpirituous or the acetous fermentation; of which laſt kind are, for inſtance, moſt animal ſubſtances. When therefore we repreſented theſe three ſorts of fermentation as three different degrees or ſtages of one and the ſame fermentation, we ſuppoſed it to be excited in a body ſuſceptible of fermentation in its full extent.

However, there is ſtill room to think that every ſubſtance which is capable of fermenting always paſſes neceſſarily through theſe three different ſtages; but that the ſubſtances moſt diſpoſed thereto paſs with ſuch rapidity through the firſt, and even the ſecond, that they arrive at the third before our ſenſes can perceive the leaſt ſigns of either of the two former. This opinion is not deſtitute of probability: yet it is not ſupported by proofs ſufficiently ſtrong and numerous to compel our aſſent.

When a body is in a putrefying ſtate it is eaſy to diſcover (as in the two ſorts of fermentation already treated of) by the vapours which riſe from it, by the opacity which invades it, if a pellucid liquor, and frequently even by a greater degree of heat than is found in the two other ſorts of fermentation, that an inteſtine motion is begun among its conſtituent parts, which laſts till the whole be entirely putrified.

The effect of this inteſtine motion is in this, as in the two other ſorts of fermentation, to break the union, and change the diſpoſition, of the particles conſtituting the body in which it is excited, and to produce a new combination. This is brought about by a mechaniſm to which we are ſtrangers, and concerning which nothing beyond conjectures can be advanced: but theſe we neglect, reſolving to keep wholly to facts, as the only things in Natural Philoſophy that are poſitively certain.

If, then, we examine a ſubſtance that has undergone putrefaction, we ſhall ſoon perceive that it contains a principle which did not exiſt in it before. If this ſubſtance be diſtilled, there riſes, firſt, by means of a very gentle heat, a ſaline matter which is exceedingly volatile, and affects the organ of ſmelling briſkly and diſagreeably. Nor is the aid of diſtillation neceſſary to diſcover the preſence of this product of putrefaction: it readily manifeſts itſelf in moſt ſubſtances where it exiſts, as any one may ſoon be convinced by obſerving the different ſmell of freſh and of putrefied urine; for the latter not only affects the noſe, but even makes the eyes ſmart, and irritates them ſo as to draw tears from them in abundance.

This ſaline principle which is the product of putrefaction, when ſeparated from the other principles of the body which affords it, and collected by itſelf, appears either in the form of a liquor, or in that of a concrete ſalt, according to the different methods uſed to obtain it. In the former ſtate it is called a *Volatile Urinous Spirit;* and in the latter a *Volatile Urinous Salt.* The qualification of urinous is given it, becauſe, as was ſaid, a great deal thereof is generated in putrefied urine, to which it communicates its ſmell. It goes alſo by the general name of a *Volatile Alkali*, whether in a concrete or in a liquid form. The enumeration of its properties will ſhew why it is called an alkali.

Volatile Alkalis, from whatever ſubſtance obtained, are all alike, and have all the ſame properties; differing only according to their degrees of purity. The Volatile Alkali, as well as the Fixed, conſiſts of a certain quantity of acid combined with and entangled by a portion of the earth of the mixt body from which it was obtained; and on that account it has many properties like thoſe of a Fixed Alkali. But there is moreover in its compoſition a conſiderable quantity of a fat or oily matter, of which there is none in a Fixed Alkali; and on this account again there is a great difference between them. Thus the Volatility of the Alkali produced by putrefaction, which is the principal difference between it and the other kind of Alkali whoſe nature it is to be Fixed, muſt be attributed to the portion of oil which it contains: for there is a certain method of volatilizing Fixed Alkalis by means of a fatty ſubſtance.

Volatile Alkalis have a great affinity with acids, unite therewith rapidly and with ebullition, and form with them neutral ſalts, which ſhoot into cryſtals, but differ from one another according to the kind of acid employed in the combination.

The neutral ſalts which have a Volatile Alkali for their baſis are in general called *Ammoniacal Salts*. That whoſe acid is the acid of ſea-ſalt is called *Sal Ammoniac*. As this was the firſt known, it gave name to all the reſt. Great quantities of this ſalt are made in Egypt, and thence brought to us. They ſublime it from the ſoot of cow's dung, which is the fuel of that country, and contains ſea-ſalt, together with a Volatile Alkali, or at leaſt the materials proper for forming it; and conſequently all the ingredients that enter into the compoſition of Sal Ammoniac. See the Memoirs of the Academy of Sciences.

The neutral ſalts formed by combining the acids of nitre and of vitriol with a Volatile Alkali are called, after their acids, *Nitrous Sal Ammoniac*, and *Vitriolic Sal Ammoniac*: the latter, from the name of its inventor, is alſo called Glauber's *Secret Sal Ammoniac*.

A Volatile Alkali, then, has the ſame property as a Fixed Alkali with regard to acids: yet they differ in this, that the affinity of the former with acids is weaker than that of the latter: and hence it follows, that any Sal Ammoniac may be decompounded by a Fixed Alkali, which will lay hold of the acid, and diſcharge the Volatile Alkali.

A Volatile Alkali will decompound any neutral ſalt which has not a Fixed Alkali for its baſis; that is, all ſuch as conſiſt of an acid combined with an abſorbent earth or a metallic ſubſtance. By joining with the acids in which they are diſſolved, it diſengages the earths or metallic ſubſtances, takes their place, and, in conjunction with their acids, forms Ammoniac Salts.

Hence it might be concluded, that, of all ſubſtances, next to the Phlogiſton and the Fixed Alkalis, Volatile Alkalis have the greateſt affinity with acids in general. Yet there is ſome difficulty in this matter: for abſorbent earths, and ſeveral metallic ſubſtances, are alſo capable of decompounding Ammoniacal Salts, diſcharging their volatile Alkali, and forming new compounds by uniting with their acids. This might induce us to think, that theſe ſubſtances have nearly the ſame affinity with acids.

But it is proper to obſerve, that a Volatile Alkali decompounds ſuch neutral ſalts as have for their baſis either an abſorbent earth or a metallic ſubſtance, without the aid of fire; whereas abſorbent earths or metallic ſubſtances will not decompound an Ammoniacal Salt, unleſs they be aſſiſted by a certain degree of heat.

Now, as all theſe matters are extremely fixed, at leaſt in compariſon with a Volatile Alkali, they have the advantage of being able to reſiſt the force of fire, and ſo of acting in conjunction therewith; and fire greatly promotes the natural action of ſubſtances upon one another: whereas the Volatile Alkali in the Ammoniacal Salt, being unable to abide the force of fire, is compelled to deſert its acid; and that ſo much the more quickly, as its affinity therewith is conſiderably weakened by the preſence of an earthy or metallic ſubſtance, both of which have a great affinity with acids.

Theſe conſiderations oblige us to conclude, that Volatile Alkalis have a ſomewhat greater affinity, than abſorbent earths and metallic ſubſtances, with acids.

Ammoniacal Salts projected upon nitre in fuſion make it detonate; and the Nitrous Sal Ammoniac detonates by itſelf, without the addition of any inflammable matter. This ſingular effect evidently demonſtrates the exiſtence of an oily matter in Volatile Alkalis; for it is certain that nitre will never deflagrate without the concurrence, and even the immediate contact, of ſome combuſtible matter.

This oily ſubſtance is often found combined with Volatile Alkalis in ſuch a large proportion as to diſguiſe it, in ſome meaſure, and render it exceedingly foul. The ſalt may be freed from its ſuperfluous oil by repeated ſublimations; and particularly by ſubliming it from abſorbent earths, which readily drink up oils. This is called the *Rectification* of a Volatile Alkali. The ſalt, which before was of a yellowiſh or dirty colour, by being thus rectified becomes very white, and acquires an odour more pungent and leſs fetid than it had at firſt, that is, when obtained by one ſingle diſtillation from a putrid ſubſtance.

It is proper to obſerve, that the rectification of a Volatile Alkali muſt not be carried too far, or repeated too often; for by that means it may be entirely decompoſed at length; and particularly if an abſorbent earth, and eſpecially chalk, be employed for that purpoſe, the ſalt may be converted into an oil, an earth, and water.

Volatile Alkalis act upon ſeveral metallic ſubſtances, and particularly on copper; of which they make a moſt beautiful blue ſolution. On this property depends a pretty ſingular effect, which happens ſometimes when we attempt, by means of a Volatile Alkali, to ſeparate copper from any acid with which it is combined. Inſtead of ſeeing the liquor grow turbid, and the metal fall, both which generally happen when any Alkali whatever is mixed with a metallic ſolution, we are ſurpriſed to obſerve the ſolution of copper, upon adding a Volatile Alkali, retain its limpidity, and let fall no precipitate; or at leaſt, if the liquor does grow turbid, it remains ſo but for a moment, and inſtantly recovers its tranſparency.

This is occaſioned by adding ſuch a quantity of Volatile Alkali as is more than ſufficient fully to ſaturate the acid of the ſolution, and conſiderable enough to diſſolve all the copper as faſt as it is ſeparated from the acid. On this occaſion the liquor acquires a deeper blue than it had before; which ariſes from the property which Volatile Alkalis have of giving this metal, when combined with them, a fuller blue than any other ſolvent can: hence we have a touchſtone to diſcover copper wherever it is; for let the quantity of this metal combined with other metals be ever ſo ſmall, a Volatile Alkali never fails to diſcover it, by making it appear of a blue colour.

Though a Volatile Alkali be conſtantly the reſult of putrefaction, yet it muſt not therefore be imagined that none can be produced by any other means; on the contrary, moſt of thoſe ſubſtances which contain the ingredients neceſſary to form it, yield no inconſiderable quantity thereof in diſtillation. Tartar, for example, which by being burnt in an open fire is converted, as was ſhewn, into a Fixed Alkali, yields a Volatile Alkali when it is decompoſed in cloſe veſſels; that is, when it is diſtilled; becauſe, in this latter caſe, the oily part is not diſſipated or burnt, as it is by calcination in a naked fire, but has time to unite with ſome of the earth and acid of the mixt, in ſuch a manner as to form a true Volatile Alkali.

To prove that on this occaſion, as well as on all others, where unputrefied bodies yield a Volatile Alkali, this ſalt is the product of the fire, we need only obſerve, that in theſe diſtillations it never riſes till after ſome part of the phlegm, of the acid, and even of the thick oil of the mixt, is come over; which never is the caſe when it is formed beforehand in the body which is the ſubject of the operation, as it is in thoſe which have undergone putrefaction: for this ſalt, being much lighter and more volatile than thoſe other ſubſtances, riſes of courſe before them in diſtillation.

CHAP. XVI.

A General View of CHYMICAL DECOMPOSITION.

THOUGH we have conſidered all the ſubſtances which enter into the compoſition of Vegetables, Animals, and Minerals, whether as primary or as ſecondary principles, it will not be improper to ſhew in what order we obtain theſe principles from the ſeveral mixts; and eſpecially from Vegetables and Animals, becauſe they are much more complicated than Minerals. This is called *Analyſing* a compound.

The method moſt commonly taken to decompoſe bodies is by applying to them ſucceſſive degrees of heat, from the gentleſt to the moſt violent, in appropriated veſſels, ſo contrived as to collect what exhales from them. By this means the principles are gradually ſeparated from each other; the moſt volatile riſe firſt, and the reſt follow in order, as they come to be acted on by the proper degree of heat: and this is called *Diſtillation*.

But it being obſerved that fire, applied to the decompoſition of bodies, moſt commonly alters their ſecondary principles very ſenſibly, by combining them in a different manner with each other, or even partly decompoſing them, and reducing them to their primitive principles; other means have been uſed to ſeparate thoſe principles without the help of fire.

With this view the mixts to be decompoſed are forcibly compreſſed, in order to ſqueeze out of them all ſuch parts of their ſubſtance as they will by this means part with: or elſe thoſe mixts are for a long time triturated, either along with water, which carries off all their ſaline and ſaponaceous contents, or with ſolvents, ſuch as ardent ſpirits, capable of taking up every thing in them that is of an oily or reſinous nature.

We ſhall here give a ſuccinct account of the effects of theſe different methods, as applied to the principal ſubſtances among Vegetables and Animals, and likewiſe to ſome Minerals.

SECTION I.

The ANALYSIS *of* VEGETABLE SUBSTANCES.

A vaſt many vegetable ſubſtances, ſuch as kernels and ſeeds, yield, by ſtrong compreſſion, great quantities of mild, fat, unctuous Oils, which are not ſoluble in ardent ſpirits: theſe are what we called *Expreſſed Oils*. They are alſo ſometimes called *Fat Oils*, on account of their unctuouſneſs, in which they exceed all other ſorts of Oil. As theſe oils are obtained without the aid of fire, it is certain that they exiſted in the mixt juſt as we ſee them, and that they are not in the leaſt altered: which could not have been the caſe had they been obtained by diſtillation; for that never produces any Oils but ſuch as are acrid and ſoluble in ſpirit of wine.

Some vegetable matters, ſuch as the rind of citrons, lemons, oranges, *&c.* alſo yield, only by being ſqueezed between the fingers, a great deal of Oil. This ſpirts out in fine ſmall jets, which being received upon any poliſhed ſurface, ſuch as a looking-glaſs, run together and form a liquor that is a real Oil.

But it muſt be carefully noted, that this ſort of Oil, though obtained by expreſſion only, is nevertheleſs very different from the Oils mentioned before, to which the title of *Ex-*

preſſed Oils peculiarly belongs: for this is far lighter and thinner; moreover, it retains the perfect odour of the fruit which yields it, and is ſoluble in ſpirit of wine; in a word, it is a true eſſential Oil, but abounds ſo in the fruits which produce it, and is lodged therein in ſuch a manner, occupying a vaſt number of little cells provided in the peel for its reception, that a very ſlight preſſure diſcharges it; which is not the caſe with many other vegetables that contain an eſſential Oil.

Succulent and green plants yield by compreſſion a great deal of liquor or juice, which conſiſts of moſt of the phlegm, of the ſalts, and a ſmall portion of the oil and earth of the plant. Theſe juices, being ſet in a cool place for ſome time, depoſite ſaline cryſtals, which are a combination of the acid of the plant with part of its oil and earth, wherein the acid is always predominant. Theſe ſalts, as is evident from the deſcription here given, bear a great reſemblance to the tartar of wine treated of above. They are called *Eſſential Salts;* ſo that Tartar might likewiſe be called the *Eſſential Salt of Wine.*

Dried plants, and ſuch as are of a ligneous, or acid nature, require to be long triturated with water, before they will yield their eſſential ſalts. Trituration with water is an excellent way to get out of them all their ſaline and ſaponaceous contents.

A vegetable matter that is very oily yields its eſſential ſalt with much difficulty, if at all; becauſe the exceſſive quantity of oil entangles the ſalt ſo that it cannot extricate itſelf or ſhoot into cryſtals. Mr. Gerike, in his *Principles of Chymiſtry*, ſays, that if part of the oil of a plant be extracted by ſpirit of wine, its eſſential ſalt may be afterwards obtained with more eaſe and in greater quantity. This muſt be a very good method for ſuch plants as have an exceſſive proportion of eſſential oil; but will not ſucceed if the eſſential ſalt be hindered from cryſtallizing by a redundancy of fat oil, becauſe fat oils are not ſoluble in ſpirit of wine.

Eſſential Salts are among thoſe ſubſtances which cannot be extracted from mixts by diſtillation: for the firſt impreſſion of fire decompoſes them.

Though the acid which predominates in the Eſſential Salts of plants, be moſt commonly analogous to the vegetable acid, properly ſo called, that is, to the acid of vinegar and tartar, which is probably no other than the vitriolic acid diſguiſed; yet it ſometimes differs therefrom, and ſomewhat reſembles the nitrous or the marine acid. This depends on the places where the plants grow which produce theſe ſalts: if they be maritime plants, their acid is akin to the acid of ſea-ſalt; if on the contrary they grow upon walls, or in nitrous grounds, their acid is like that of nitre. Sometimes one and the ſame plant contains ſalts analogous to all the three mineral acids; which ſhews that the vegetable acids are no other than the mineral acids variouſly changed by circulating through plants.

Liquors containing the Eſſential Salts of plants being evaporated by a gentle heat to the conſiſtence of honey, or even further, are called *Extracts*. Hence it is plain, that an Extract is nothing but the eſſential ſalt of a plant, combined with ſome particles of its oil and earth, that remained ſuſpended in the liquor, and are now incorporated by evaporation.

Extracts of plants are alſo prepared by boiling them long in water, and then evaporating ſome part of it. But theſe Extracts are of inferior virtue; becauſe the fire diſſipates many of the oily and ſaline parts.

EMULSIONS.

Subſtances which abound much in Oil, being bruiſed and triturated with water for ſome time, afford a liquor of an opaque dead-white colour, like milk. This liquor conſiſts of ſuch juices as the water is capable of diſſolving, together with a portion of the oil, which being naturally indiſſoluble in water, is only divided and diſperſed in the liquor, the limpidity whereof is by that means deſtroyed. This ſort of oily liquor, in which the oil is only divided, not diſſolved, is called an *Emulſion*. The oily particles in Emulſions ſpontaneouſly ſeparate from the water, when left at reſt, and uniting into greater maſſes riſe, on account of their lightneſs, to the ſurface of the liquor, which by that means recovers a degree of tranſparency.

If vegetables abounding in eſſential oils and reſins be digeſted in ſpirit of wine, the menſtruum takes up theſe oily matters, as being capable of diſſolving them; and they may afterwards be eaſily ſeparated from it by the affuſion of water. The water, with which ſpirit of wine has a greater affinity than with oily matters, ſeparates them by this means from their ſolvent, agreeably to the common laws of affinities.

Without the help of fire, ſcarce any thing, beſides the ſubſtances already mentioned, can be obtained from a plant:

but, by the means of diſtillation, we are enabled to analyſe them more completely. In proſecuting this method of extracting from a plant the ſeveral principles of which it conſiſts, the following order is to be obſerved.

A plant being expoſed to a very gentle heat, in a diſtilling veſſel ſet in the *balneum mariæ*, yields a water which retains the perfect ſmell thereof. Some Chymiſts, and particularly the illuſtrious Boerhaave, have called this liquor the *Spiritus Rector*. The nature of this odoriferous part of plants is not yet thoroughly known; becauſe it is ſo very volatile that it is difficult to ſubject it to the experiments neceſſary for diſcovering all its properties.

If, inſtead of diſtilling the plant in the *balneum mariæ*, it be diſtilled over a naked fire, with the precaution of putting a certain quantity of water into the diſtilling veſſel along with it, to prevent its ſuffering a greater heat than that of boiling water, all the eſſential oil contained in that plant will riſe together with that water, and with the ſame degree of heat.

On this occaſion it muſt be obſerved, that no eſſential oil can be obtained from a plant after the *Spiritus Rector* hath been drawn off; which gives ground to think that the volatility of theſe oils is owing to that ſpirit.

The heat of boiling water is alſo ſufficient to ſeparate from vegetable matters the fat oils which they contain. That, however, is to be done by the way of decoction only, and not by diſtillation: becauſe, though theſe oils will ſwim on water, yet they will not riſe in vapours without a greater degree of heat.

When the eſſential oil is come over, if the plant be expoſed to a naked fire, without the addition of water, and the heat be increaſed a little, a phlegm will riſe that gradually grows acid; after which, if the heat be increaſed as occaſion requires, there will come over a thicker and heavier oil; from ſome a volatile alkali; and laſt of all, a very thick, black, empyreumatic oil.

When nothing more riſes with the ſtrongeſt degree of heat, there remains of the plant a mere coal only, called the *Caput Mortuum*, or *Terra Damnata*. This coal when burnt falls into aſhes, which, being lixiviated with water, give a fixed alkali.

It is obſervable, that in the diſtillation of plants which yield an acid and a volatile alkali, theſe two ſalts are often found quite diſtinct and ſeparate in the ſame receiver; which ſeems very extraordinary, conſidering that they are naturally diſpoſed to unite, and have a great affinity with one another. The reaſon of this phenomenon is, that they are both combined with much oil, which embarraſſes them ſo that they cannot unite to form a neutral ſalt, as they would not fail to do were it not for that impediment.

All vegetables, except ſuch as yield a great deal of volatile alkali, being burnt in an open fire, and ſo as to flame, leave in their aſhes a large quantity of an acrid, cauſtic, fixed alkali. But if care be taken to ſmother them, ſo as to prevent their flaming while they burn, by covering them with ſomething that may continually beat down again what exhales, the ſalt obtained from their aſhes will be much leſs acrid and cauſtic; the cauſe whereof is, that ſome part of the acid and oil of the plant being detained in the burning, and ſtopped from being diſſipated by the fire, combines with its alkali. Theſe ſalts cryſtallize, and, being much milder than the common fixed alkalis, may be uſed in medicine, and taken internally. They are called *Tachenius*'s *Salts*, becauſe invented by that Chymiſt.

Marine plants yield a fixed alkali analogous to that of ſea-ſalt. As for all other plants or vegetable ſubſtances, the fixed alkalis obtained from them, if rightly prepared and thoroughly calcined, are all perfectly alike, and of the very ſame nature.

The laſt obſervation I have to make on the production of fixed alkalis is, that if the plant you intend to work upon be ſteeped or boiled in water before you burn it, a much ſmaller quantity of ſalt will be obtained from it; nay, it will yield none at all, if repeated boilings have robbed it entirely of thoſe ſaline particles which muſt neceſſarily concur with its earth to form a fixed Alkali.

SECTION II.

The ANALYSIS *of* ANIMAL SUBSTANCES.

SUCCULENT animal ſubſtances, ſuch as new-killed fleſh, yield by expreſſion a juice or liquid, which is no other than the phlegm, replete with all the principles of the animal body, except the earth, of which it contains but little. The hard or dry parts, ſuch as the horns, bones, *&c.* yield a ſimilar juice, by boiling them in water. Theſe juices become thick, like a glue or jelly, when their watery parts are evaporated; and, in this ſtate, they are truly extracts of animal matters. Theſe juices afford no cryſtals of eſſential ſalt, like thoſe obtained from vegetables, and ſhew no ſign either of an acid or an alkali.

Great part of the oil which is in the fleſh of animals may be eaſily ſeparated without the help of fire; for it lies in a manner by itſelf: it is commonly in a concrete form, and is called *Fat*. This oil ſomewhat reſembles the fat oils of vegetables; for like them it is mild, unctuous, indiſſoluble in ſpirit of wine, and is ſubtilized and attenuated by the action of fire. But there is not in animals, as in vegetables, any light eſſential oil, which riſes with the heat of boiling water; ſo that, properly ſpeaking, animals contain but one ſort of oil.

Few animal ſubſtances yield a perceptible acid. Ants and bees are almoſt the only ones from which any can be obtained: and indeed the quantity they yield is very ſmall, as the acid itſelf is extremely weak.

The reaſon thereof is, that as animals do not draw their nouriſhment immediately from the earth, but feed wholly either on vegetables or on the fleſh of other animals, the mineral acids, which have already undergone a great change by the union contracted between them and the oily matters of the vegetable kingdom, enter into a cloſer union and combination with theſe oily parts while they are paſſing through the organs and ſtrainers of animals; whereby their properties are deſtroyed, or at leaſt ſo impaired, that they are no longer ſenſible.

Animal matters yield in diſtillation, firſt, a phlegm, and then, on increaſing the fire, a pretty clear oil, which gradually becomes thicker, blacker, more fetid, and empyreumatic. It is accompanied with a great deal of volatile alkali; and if the fire be raiſed and kept up till nothing more comes over, there will remain in the diſtilling veſſel a coal like that of vegetables; except that when it is reduced to aſhes, no fixed alkali, or at leaſt very little, can be obtained from them, as from the aſhes of vegetables. This ariſes from hence, that, as we ſaid before, the ſaline principle in animals being more intimately united with the oil than it is in plants, and being conſequently more attenuated and ſubtilized, is too volatile to enter into the combination of a fixed alkali; on the contrary, it is more diſpoſed to join in forming a volatile alkali, which on this occaſion does not riſe till after the oil, and therefore muſt certainly be the production of the fire. It muſt be obſerved, that all we have hitherto ſaid concerning the analyſis of bodies muſt be underſtood of ſuch matters only as have not undergone any ſort of Fermentation.

The chyle and milk of animals which feed on plants ſtill retain ſome likeneſs to vegetables; becauſe the principles of which theſe liquors are compoſed have not gone through all the changes which they muſt ſuffer before they enter into the animal combination.

Urine and ſweat are excrementitious aqueous liquors, loaded chiefly with the ſaline particles which are of no ſervice towards the nouriſhment of the animal, but paſs through its ſtrainers without receiving any alteration; ſuch as the neutral ſalts which have a fixed alkali for their baſis, and particularly the ſea-ſalt, which happens to be in the food of animals, whether it exiſt therein naturally, as it does in ſome plants, or whether the animals eat it to pleaſe their palates.

The ſaliva, the pancreatic juice, and eſpecially the bile, are ſaponaceous liquors, that is, they conſiſt of ſaline and oily particles combined together: ſo that being themſelves diſſolved in an aqueous liquor, they are capable of diſſolving likewiſe the oily parts, and of rendering them miſcible with water.

Laſtly, the blood being the receptacle of all theſe liquors partakes of the nature of each, more or leſs in proportion to the quantity thereof which it contains.

SECTION III.

The ANALYSIS *of* MINERAL SUBSTANCES.

MINERALS differ greatly from vegetables, and from animals; they are not near ſo complex as thoſe organized bodies, and their principles are much more ſimple; whence it follows, that theſe principles are much more cloſely connected, and that they cannot be ſeparated without the help of fire; which not having on their parts the ſame action and the ſame power as on organized bodies, hath not the ſame ill effect on them; I mean the effect of changing their principles, or even deſtroying them entirely.

I do not here ſpeak of pure, vitrifiable, or refractory earths; of mere metals and ſemi-metals; of pure acids; or even of their ſimpleſt combinations, ſuch as ſulphur, vitriol, alum, ſea-ſalt: of all theſe we have ſaid enough.

We are now to treat of bodies that are more complex, and therefore more ſuſceptible of decompoſition. Theſe bodies are compound maſſes, or combinations of thoſe above-mentioned; that is, metallic ſubſtances as they are found in the bowels of the earth, united with ſeveral ſorts of ſand, ſtones, earths, ſemi-metals, ſulphur, *&c.* When the metallic matter is combined with other matters, in ſuch a proportion to the reſt that it may be ſeparated from them with advantage and profit, theſe compounds are called *Ores:* when the caſe is otherwiſe, they are called *Pyrites*, and *Marcaſites;* eſpecially if ſulphur or arſenic be predominant therein, which often happens.

In order to analyſe an ore, and get out of it the metal it contains, the firſt ſtep is to free it from a great deal of earth and ſtones, which commonly adhere to it very ſlightly and ſuperficially. This is effected by pounding the ore, and then waſhing it in water; to the bottom of which the metalline parts preſently ſink, as being the heavieſt, while the ſmall particles of earth and ſtone remain ſuſpended ſome time longer.

Thus the metallic part is left combined with ſuch matters only as are moſt intimately complicated with it. Theſe ſubſtances are moſt commonly ſulphur and arſenic. Now, as they are much more volatile than other mineral matters, they may be diſſipated in vapours, or the ſulphur may be conſumed, by expoſing the ore which contains them to a proper degree of heat. If the ſulphur and arſenic be deſired by themſelves, the fumes thereof may be catched and collected in proper veſſels and places. This operation is called *Roaſting* an Ore.

The metal thus depurated is now fit to be expoſed to a greater force of fire, capable of melting it.

On this occaſion the ſemi-metals and the imperfect metals require the addition of ſome matter abounding in phlogiſton, particularly charcoal-duſt; becauſe theſe metallic ſubſtances loſe their phlogiſton by the action of the fire, or of the fluxes joined with them, and therefore without this precaution would never acquire either the ſplendour or the ductility of a metal. By this means the metallic ſubſtance is more accurately ſeparated from the earthy and ſtony parts, of which ſome portion always remains combined therewith till it is brought to fuſion. For, as we obſerved before, a metallic glaſs or calx only will contract an union with ſuch matters; a metal poſſeſſed of its phlogiſton and metalline form being utterly incapable thereof.

We took notice of the cauſe of this ſeparation above, where we ſhewed that a metal poſſeſſed of its phlogiſton and metalline

line form will not remain intimately united with any calcined or vitrified matter, not even with its own calx or glaſs.

The metal therefore on this occaſion gathers into a maſs, and lies at the bottom of the veſſel, as being moſt ponderous; while the heterogeneous matters float upon it in the form of a glaſs, or a ſemi-vitrification. Theſe floating matters take the name of *Scoriæ*, and the metalline ſubſtance at bottom is called the *Regulus*.

It frequently happens, that the metalline regulus thus precipitated is itſelf a compound of ſeveral metals mixed together, which are afterwards to be ſeparated. We cannot at preſent enter into a detail of the operations neceſſary for that purpoſe: they will appear in our Treatiſe of *Practical Chymiſtry*: but the principles on which they are founded may be deduced from what we have ſaid above, concerning the properties of the ſeveral metals and of acids.

It is proper to obſerve, before we quit this ſubject, that the rules here laid down for analyſing ores are not abſolutely general: for example, it is often adviſeable to roaſt the ore before you waſh it; for by that means ſome ores are opened, attenuated, and made very friable, which would coſt much trouble and expence, on account of their exceſſive hardneſs, if you ſhould attempt to pound them without a previous torrefaction.

It is alſo frequently neceſſary to ſeparate the ore from part only of its ſtone; ſometimes to leave the whole; and ſometimes to add more to it, before you ſmelt it. This depends on the quality of the ſtone, which always helps to promote fuſion when it is in its own nature fuſible and vitrifiable. It is then called the *Fluor* of the ore: but of this we muſt ſay, as we did of the preceding article, it is ſufficient for our preſent purpoſe to lay down the fundamental principles on which the reaſon of every proceſs is built; the deſcription of the operations themſelves being reſerved for our ſecond Part.

We ſhall now give a ſuccinct account of the principal ores and mineral bodies, contenting ourſelves with juſt pointing out the particulars of which they ſeverally conſiſt.

Of the PYRITES.

The yellow Pyrites.

THE yellow Pyrites is a mineral conſiſting of ſulphur, iron, an unmetallic earth, and frequently a little copper:

the ſulphur, which is the only one of theſe principles that is volatile, may be ſeparated from the reſt by ſublimation: it uſually makes a fourth, and ſometimes a third, of the whole weight of theſe Pyrites. The other principles are ſeparated from one another by fuſion and reduction with the phlogiſton, which, by metallizing the ferruginous and cupreous earths, parts them from the unmetallic earth: for this earth vitrifies, and cannot afterwards continue united with metallic matters poſſeſſed of their metalline form, as hath been ſaid before.

There is yet another way of decompoſing the yellow Pyrites, which is to let it ly till it effloreſces, or begins to ſhoot into flowers; which is nothing but a ſort of ſlow accenſion of the ſulphur it contains. The ſulphur being by this means decompoſed, its acid unites with the ferruginous and cupreous parts of the Pyrites, and therewith forms green and blue vitriols; which may be extracted by ſteeping in water the Pyrites which has effloreſced or been burnt, and then evaporating the lixivium to a pellicle; for by this means the vitriol will ſhoot into cryſtals.

Sometimes the Pyrites contains alſo an earth of the ſame nature with that of alum; a Pyrites of this ſort, after flowering, yields alum as well as vitriol.

The white Pyrites.

THE white Pyrites contains much arſenic, a ferruginous earth, and an unmetallic earth. The arſenic, being a volatile principle, may be ſeparated by ſublimation or diſtillation from the reſt, which are fixed: and theſe again may be disjoined from each other by fuſion and reduction, as was ſaid in relation to the yellow Pyrites.

The Copper Pyrites.

THE Copper Pyrites contains ſulphur, copper, and an unmetallic earth. A great deal thereof likewiſe holds arſenic, and its colour approaches more or leſs to orange, yellow, or white, according to the quantity of arſenic in it. It may be decompoſed by the ſame means as the yellow and white Pyrites.

Of ORES.

Of Gold Ores.

GOLD being conſtantly found in its metalline form, and never combined with ſulphur and arſenic, its matrices are not, properly ſpeaking, ores; becauſe the metal contained in them is not mineralized. The gold is only lodged between particles of ſtone, earth, or ſand, from which it is eaſily ſeparated by lotion, and by amalgamation with quickſilver. The gold thus found is ſeldom pure, but is frequently alloyed with more or leſs ſilver, from which it is to be ſeparated by quartation.

It is alſo very common to find gold in moſt ores of other metals or ſemi-metals, and even in the Pyrites; but the quantity contained therein is generally ſo ſmall, that it would not pay the coſt of extracting it. However, if any ſhould incline to attempt it, merely out of curioſity, it would be neceſſary to begin with treating theſe ores in the manner proper for ſeparating their metalline part; then to cupel the metalline regulus ſo obtained; and, laſtly, to refine it by quartation.

Of Silver Ores.

IT is no rare thing to find ſilver, as well as gold, in its metalline form, only lodged in ſundry earths and ſtony matters, from which it may be ſeparated in the ſame manner as gold. But the greateſt quantities of this metal are uſually dug out of the bowels of the earth in a truly mineral ſtate: that is, combined with different ſubſtances, and particularly with ſulphur and arſenic.

Several ſilver ores are diſtinguiſhed by peculiar characteriſtics, and are accordingly denoted by particular names. That which is called the *Vitreous Silver Ore*, is ſcarce any thing elſe but a combination of ſilver and ſulphur. Another is known by the name of the *Horny Silver Ore*, becauſe when in thin plates it is ſemi-tranſparent: in this ore the ſilver is mineralized by ſulphur and a little arſenic. The *Red Silver Ore* is of the colour which its name imports, ſometimes more, ſometimes leſs vivid; and is chiefly compoſed of ſilver, arſenic, and ſulphur: it alſo contains a little iron.

Theſe three ores are very rich in ſilver: the firſt contains nearly three fourths of its weight, and the others about two thirds of theirs.

There is a fourth, called the *White Silver Ore*, which, though it be heavier, is not ſo rich in ſilver, becauſe it contains much copper. Many other minerals contain ſilver, yet are not, properly ſpeaking, ſilver ores; becauſe a much greater quantity of other metals than of ſilver is found in them.

When a ſilver ore is to be decompoſed, in order to have the ſilver pure, or when ſilver is to be extracted out of any ore that contains it, the firſt thing to be done is to roaſt the ore, in order to clear it of the volatile minerals: and as ſilver cannot be had pure without the operation of the cupel, which requires more or leſs lead to be joined with it, it is uſual to mix with the torrified ſilver ore a quantity of lead, proportioned to that of the heterogeneous matters combined with the ſilver, and to melt the whole together. Part of the added lead vitrifies during the fuſion, and at the ſame time converts ſome of the heterogeneous matters alſo into glaſs, with which it forms a ſcoria that riſes to the ſurface of the matter. The other part of the lead, with which the ſilver is mixed, falls to the bottom in the form of a regulus, which muſt be cupelled in order to have the ſilver pure.

Of Copper Ores.

COPPER is much ſeldomer found in a metalline form than gold or ſilver: it is commonly in a mineral ſtate: it is mineralized by ſulphur and arſenic: almoſt all its ores contain alſo more or leſs of iron; ſometimes a little ſilver, or even gold, together with unmetallic earths and ſtones, as all ores do.

Moſt copper ores are of a beautiful green or blue, or elſe in ſhades blended of theſe two colours. The minerals called *mountain green*, and *mountain blue*, are true copper ores; not in the form of hard ſtones, like other ores, but crumbly and friable like earth.

Nevertheleſs, there are ſeveral copper ores of different colours, as aſh-coloured, whitiſh, and ſhaded with yellow or orange; which colours ariſe from the different proportions of arſenic, ſulphur, and iron, which theſe ores contain.

In order to decompoſe a copper ore, and to extract the copper it contains, it is firſt of all to be freed from as many of its earthy, ſtony, ſulphureous, and arſenical parts, as is poſſible, by roaſting and waſhing; then what remains is to be mixed with a flux, compounded of a fixed alkali and ſome inflammable matter; a little ſea-ſalt is to be put over all, and the whole melted by a ſtrong fire. The ſalts facilitate the fuſion and ſcorification of the unmetallic matters, and therewith form a ſlag, which being the lighteſt riſes to the ſurface. The metalline matters are collected below in the form of a ſhining regulus of copper; which, however, is not uſually fine copper, but requires to be purified in the manner to be ſhewn in our ſecond part.

In order to ſeparate the copper from the unmetallic matters, it is abſolutely neceſſary to melt its ore along with inflammable ſubſtances abounding in phlogiſton. For, as this metal is not poſſeſſed of its metalline form while it is in a mineral ſtate, as it is deſtitute of the true quantity of phlogiſton, and, though it were not, would loſe it by the action of the fire, it would come to paſs, that if its ore were melted without the addition of any inflammable matter, the cupreous earth or calx would be ſcorified and confounded with the unmetallic matters; and as all metallic matters, except gold and ſilver, are ſubject to this inconvenience as well as copper, the addition of an inflammable ſubſtance, in fluxing all ores that contain them, is a general rule that ought conſtantly to be obſerved.

Of Iron Ores.

Iron is ſeldom found pure and malleable in the earth; yet it is much ſeldomer found in the mineral ſtate, properly ſo called, than any of the other metals: for moſt iron ores are ſcarce any thing more than a ferruginous earth mixed in different proportions with unmetallic earths and ſtones. Some of them, however, contain alſo volatile minerals, ſuch as ſulphur and arſenic; and therefore it is neceſſary to roaſt the iron ores, like all others, before you attempt to extract the metal out of them. That being done, they are to be ſmelted with a flux conſiſting of fuſible and inflammable matters, as the general rule directs.

Iron is the commoneſt of all metals: nay, it is ſo univerſally diffuſed through the earth, that it is difficult to find any ſtone, earth, or ſand, that does not contain ſome of it; and therefore none of theſe are uſually conſidered and treated as iron ores, except ſuch as contain a great deal of that metal, and melt eaſily. The hematites, emery, yellow pyrites, calamine, all contain a pretty conſiderable quantity of iron; but no body attempts to extract it from them, becauſe they are very hard to melt.

Ferruginous earth being naturally of an orange colour, a ſtone or earth may be judged to contain iron, if either naturally, or after roaſting, it appears to have one ſhade of yellow or red.

The ſingular property which iron has of being attracted by the magnet, and of being the only body, excluſive of all others, that is ſo, likewiſe affords us an eaſy method of diſcovering the preſence of this metal among other matters, where it often exiſts in ſuch a ſmall quantity that it could not otherwiſe be found out. For this purpoſe the body in which iron is ſuſpected to lurk, muſt be pulveriſed and torrefied with ſome inflammable matter; and then the powder thus roaſted being touched with a magnet, or an animated bar, if it contains any particles of iron they will infallibly adhere to the magnet or bar.

Of Tin Ores.

TIN is never found in the earth pure and malleable, but always in a mineral ſtate, and always mineralized by arſenic. Tin ores are not ſulphureous; whence it comes, that though tin be the lighteſt of all metals, its ores are nevertheleſs heavier than thoſe of other metals, as arſenic greatly exceeds ſulphur in gravity. Some tin ores contain alſo a little iron. The ores of tin are to be waſhed, roaſted, and ſmelted with a reducing flux, according to the general rules.

Of Lead Ores.

LEAD, like tin, is never found but in a mineral ſtate. It is moſt commonly mineralized by ſulphur; yet there are ſome lead ores which alſo contain arſenic.

Lead ores, as well as others, muſt be roaſted and ſmelted with a reducing flux: however, as it is difficult to free them from all their ſulphur by torrefaction only, the reducing flux employed in their fuſion may be made up with a quantity of iron filings, which being incapable of any union with lead, and having a much greater affinity than that metal with ſulphur, will, on this occaſion, be of great ſervice by interpoſing between them.

Of Quickſilver Ores.

RUNNING Mercury is ſometimes found in certain earths, or grey, friable ſtones; but moſt commonly in a mineral ſtate. It is always mineralized by ſulphur, and by ſulphur alone: ſo that cinabar is the only ore of quickſilver that we know of; and a very rich one it is, ſeeing it contains ſix or ſeven times as much mercury as ſulphur.

Roaſting can be of no uſe towards decompoſing the ore of mercury, and ſeparating its ſulphur; becauſe mercury being itſelf very volatile would be carried off by the fire together with the ſulphur. In order, therefore, to part the two ſubſtances of which cinabar conſiſts, recourſe muſt neceſſarily be had to ſome third body, which will unite with one of them, and by that means ſeparate it from the other. Now all the metals, except gold, having a greater affinity than mercury with ſulphur, ſuch a body is eaſily found: any metal but gold may be employed with ſucceſs in this decompoſition; but as iron hath a greater affinity with ſulphur than any of the reſt, and is moreover the only one that cannot unite with mercury, it muſt, on account of theſe two qualities, be preferred to all the reſt.

Fixed alkalis are alſo well qualified to abſorb the ſulphur of cinabar. Cinabar muſt be decompoſed in cloſe veſſels, and by the way of diſtillation; otherwiſe the mercury, as ſoon as it ſeparates from the ſulphur, will be diſſipated in vapours and entirely loſt.

In this operation it is needleſs to add either flux or phlogiſton; becauſe the cinabar is decompoſed without melting, and the mercury, though in a mineral ſtate, contains, like gold and ſilver, all the phlogiſton requiſite to ſecure its metalline properties.

Of the Ores of Regulus of Antimony.

REGULUS of Antimony is always found in a mineral ſtate: it is mineralized by ſulphur; but ſometimes, though rarely, it is alſo combined with a little arſenic.

When the ore of regulus of antimony is to be decompoſed, the firſt thing to be done is to expoſe it to a degree of heat too weak to melt its earthy and ſtony parts, but ſtrong enough to fuſe its reguline, together with its ſulphureous parts, which by this means are ſeparated from the earth, and united into one maſs, known by the name of Antimony.

It is plain that this firſt operation, which is founded on the great fuſibility of antimony, produces, with regard to the ore of regulus of antimony, the ſame effect that waſhing hath on other ores: ſo that after this firſt fuſion nothing more is requiſite to the obtaining of a pure regulus of antimony, but to ſeparate it from its ſulphur by roaſting, and to melt it with ſome matter abounding in phlogiſton, in the ſame manner as other metallic matters are treated. The term *Calcination* is generally uſed to expreſs this torrefaction of antimony, by means whereof the metallic earth of the regulus of antimony is ſeparated from its ſulphur.

As regulus of Antimony hath, like Mercury, much leſs affinity with ſulphur than the other metals have, it follows that antimony may be decompoſed by the ſame means as cinabar; but the regulus, ſo obtained, is adulterated with a portion of the additament made uſe of, which combines therewith.

There is ſtill another proceſs employed for obtaining the regulus of antimony: it conſiſts, as was mentioned in its place, in detonating the mineral with a mixture of nitre and tartar, applied in ſuch a proportion that, after the detonation has conſumed the ſulphur, there may remain ſo much inflammable matter as will be ſufficient to furniſh the metalline earth of the antimony with the phlogiſton neceſſary to preſerve its metallic properties. But by this method leſs regulus is produced, than by calcining, or torrefying, and reducing as uſual.

Of the Ores of Biſmuth.

THE ore of Biſmuth conſiſts of the ſemi-metal mineralized by arſenic, and of an unmetallic earth. It is very eaſy to decompoſe this ore, and to extract the biſmuth it contains: for this purpoſe it need only be expoſed to a moderate heat, whereby the arſenic will be diſſipated in vapours, and the biſmuth melted, which will then ſeparate from the unmetallic earth. This earth, at leaſt, in ſeveral ores of biſmuth, poſſeſſes the property of tinging all vitrifiable matters, with which it is melted, of a beautiful blue colour.

To decompoſe the ore of biſmuth no flux or inflammable matter is uſed; becauſe this ſemi-metal is poſſeſſed, even in its mineral ſtate, of all the phlogiſton requiſite to maintain its metalline properties; and its great fuſibility makes it unneceſſary to melt the unmetallic earth contained in its ore.

Of the Ores of Zinc.

ZINC is not generally obtained from a particular ore of its own; but ſublimes during the fuſion of a mineral, or rather a cona confuſed maſs of minerals, that contains this ſemi-metal together with iron, copper, lead, ſulphur, arſenic, and, like all other ores, an unmetallic earth.

Nevertheleſs, there is a ſubſtance which may be conſidered as the proper ore of zinc, becauſe it contains a pretty large quantity of that ſemi-metal, a little iron, and an unmetallic earth. It is called *Calamine*, or *Lapis Calaminaris*; but hitherto the art of procuring zinc directly from this mineral hath no where been practiſed. Calamine is commonly employed only to convert copper into braſs, or a yellow metal, by cementing it therewith. Indeed, till lately, no eaſy or practicable method of obtaining pure zinc from calamine was publicly known; for that ſemi-metal being volatile and very inflammable, its ore cannot be fuſed like others. Mr. Margraaf was the firſt who, by mixing powdered charcoal with calamine in cloſe veſſels, obtained a perfect zinc from it, by the means of diſtillation or ſublimation, as ſhall be ſhewn in our Practical Chymiſtry.

Of Arſenical Minerals.

ARSENIC, as well as ſulphur, is naturally combined with almoſt all ores, or minerals containing metallic ſubſtances. As it is very volatile, while the matters with which it is united are fixed, at leaſt in compariſon therewith, it is eaſily ſeparated by ſublimation.

The minerals that contain moſt arſenic are the white pyrites, orpiment, and cobalt. We have already conſidered the white pyrites: as to orpiment, it conſiſts of ſulphur and arſenic. Both theſe ſubſtances being very volatile, it is difficult to ſeparate them by ſublimation: yet, with proper management, and a due regulation of the fire, this ſeparation may be effected; becauſe ſulphur ſublimes a little more eaſily than arſenic. But it is more convenient, as well as more expeditious, to make uſe of ſome additament that hath a greater affinity with one of thoſe ſubſtances than with the other. Fixed alkalis and mercury, both of which have more affinity with ſulphur than with arſenic, may be very properly employed on this occaſion.

Cobalt is a mineral compoſed of arſenic, an unmetallic earth, and frequently biſmuth: and as none of theſe are very volatile, except the arſenic, this may be eaſily ſeparated from the reſt by ſublimation. The unmetallic earth which remains has, like that of the ore of biſmuth, the property of giving a blue colour to any vitrifiable matters melted with it; whence it is conjectured, that cobalt and the ore of biſmuth have a great reſemblance, or are often blended with each other. Nevertheleſs, Mr. Brant, an ingenious Swediſh Chymiſt, inſiſts that they are very different: he pretends that the metallic ſubſtance contained in the true cobalt is a ſemi-metal of a peculiar nature, which hath been erroneouſly confounded with biſmuth: and indeed he proves by a great number of curious experiments, related in the Memoirs of the Academy of Upſal, that theſe two metallic ſubſtances have properties that are eſſentially different: to that which is obtained from cobalt, he gives the name of *Regulus of Cobalt.*

Beſides the minerals already recited, there is found in the bowels of the earth another ſpecies of compound body, of which we have already taken notice; but which is ſuppoſed, with ſome degree of probability, to belong as much to the vegetable as to the mineral kingdom: I mean the *Bitumens;* which the beſt obſervations oblige us to conſider as vegetable oils, that by lying long in the earth have contracted an union with the mineral acids, and by that means acquired the thickneſs, conſiſtence, and other properties obſervable in them.

By diſtillation they yield an oil, and an acid not unlike a mineral acid. Mr. Bourdelin has even demonſtrated, by a very artful and ingenious proceſs, that amber contains a manifeſt acid of ſea-ſalt. See the Memoirs of the Royal Academy of Sciences.

CHAP. XVII.

Explanation of the Table of Affinities.

IT hath been ſhewn in the courſe of this work, that the cauſes of almoſt all the phenomena, which Chymiſtry exhibits, are deducible from the mutual affinities of different ſubſtances, eſpecially the ſimpleſt. We have already explained (Chap. II.) what is meant by affinities, and have laid down the principal laws to which the relations of different bodies are ſubject. The late Mr. Geoffroy, one of the beſt Chymiſts we have had, being convinced of the advantages which all who cultivate Chymiſtry would receive from having conſtantly before their eyes a ſtate of the beſt aſcertained relations between the chief agents in Chymiſtry, was the firſt who undertook to reduce them into order, and unite them all in one point of view, by means of a table. We are of opinion, with that great man, that this Table will be of conſiderable uſe to ſuch as are beginning to ſtudy Chymiſtry, in helping them to form a juſt idea of the relations which different ſubſtances have with one another; and that the practical Chymiſt will thereby be enabled to account for what paſſes in ſeveral of his operations, otherwiſe difficult to be underſtood, as well as to judge what may be expected to reſult from mixtures of different compounds. Theſe reaſons have induced us to inſert it at the end of this Elementary Treatiſe, and to give a ſhort explanation of it here; eſpecially as it will ſerve, at the ſame time, for a recapitulation of the whole work, in which the ſeveral axioms of this Table are diſperſed.

You have it here juſt as it was drawn up by Mr. Geoffroy, without any addition or alteration. I own, however, that it might be improved both ways: for ſince the death of that great Chymiſt many experiments have been made, ſome of which have diſcovered new affinities, and others have raiſed exceptions to ſome of thoſe laid down by him. But ſeveral reaſons diſſuade me from publiſhing a new Table of Affinities, containing all the emendations and innovations that might be made in the old one.

The firſt is, that many of the affinities lately diſcovered are not yet ſufficiently verified, but, on the contrary, ſubject to be conteſted: in ſhort, they are perhaps liable to more conſiderable objections, and exceptions, than the other.

The ſecond is, that as Mr. Geoffroy's Table contains all the fundamental affinities, it is more ſuitable to an Elementary Treatiſe than a much fuller one would be; ſeeing this would neceſſarily ſuppoſe the knowledge of many things not treated of by us, and of which it was not proper to ſay any thing in ſuch a book as this.

However, as it is eſſential to our purpoſe that we lead none into error, we ſhall take care in explaining the affinities delivered by Mr. Geoffroy, to mention the principal objections and exceptions to which they are liable: we ſhall, moreover, add a very few new ones, confining ourſelves to ſuch only as are elementary and well aſcertained.

The upper line of Mr. Geoffroy's Table, comprehends ſeveral ſubſtances uſed in Chymiſtry. Under each of thoſe ſubſtances are ranged in diſtinct columns ſeveral matters compared with them, in the order of their relation to that firſt ſubſtance; ſo as that which is the neareſt to it is that which hath the greateſt affinity with it, or that which none of the ſubſtances ſtanding below it can ſeparate therefrom; but which, on the contrary, ſeparates them all when they are combined with it, and expels them in order to join itſelf therewith. The ſame is to be underſtood of that which occupies the ſecond place of affinity; that is, it has the ſame property with regard to all below it, yielding only to that which is above it: and ſo of all the reſt.

At the top of the firſt column ſtands the character which denotes an Acid in general. Immediately under this ſtands the mark of a Fixed Alkali, being placed there as the ſubſtance which has the greateſt affinity with an Acid. After the Fixed Alkali appears the Volatile Alkali, whoſe affinity with Acids yields only to the Fixed Alkali. Next come the Abſorbent Earths; and laſt of all Metallic Subſtances. Hence it follows, that when a Fixed Alkali is united with an acid it cannot be ſeparated therefrom by any other ſubſtance; that a Volatile Alkali united with an Acid cannot be ſeparated from it by any thing but a Fixed Alkali; that an Abſorbent Earth combined with an acid may be ſeparated from it either by a Fixed or by a Volatile Alkali; and laſtly, that any Metallic Subſtance combined with an Acid may be ſeparated from it by a Fixed Alkali, a Volatile Alkali, or an Abſorbent Earth.

There are many important remarks to be made on this firſt column. Firſt, it is making the rule too general to ſay that any Acid whatever has a greater affinity with a Fixed Alkali, than with any other ſubſtance. And indeed Mr. Geoffroy himſelf hath made an exception with reſpect to the Vitriolic Acid; for in the fourth column, at the head of which ſtands that Acid, we find the ſign of the Phlogiſton placed above that of the Fixed Alkali, as having a greater affinity than the Fixed Alkali with the Vitriolic Acid. This is founded on the famous experiment, wherein Vitriolated Tartar and Glauber's Salt are decompounded by means of the Phlogiſton, which ſeparates the Fixed Alkalis of theſe Neutral Salts, and uniting with the Vitriolic Acid contained in them forms therewith a Sulphur.

Secondly, Nitre deflagrates, and is decompoſed, by the contact of any inflammable matter whatever that is actually ignited; and the operation which produces Phoſphorus is no other than a decompoſition of ſea-ſalt, whoſe Acid quits its Alkaline baſis to join with the Phlogiſton: now theſe facts furniſh very ſtrong reaſons for believing that both theſe

Acids, as well as the Vitriolic, have a ſtronger affinity with the Phlogiſton than with a Fixed Alkali. Laſtly, as ſeveral experiments ſhew the Vegetable Acids to be only the Mineral Acids diſguiſed and mortified, there are ſufficient grounds for ſuſpecting that Acids in general have a greater affinity with the Phlogiſton than with Fixed Alkalis : ſo that inſtead of making an exception with regard to the Vitriolic Acid, it would perhaps be better to lay down this greater affinity as common to all Acids whatever, and to place the Phlogiſton in the firſt column, immediately under the character which denotes an Acid in general. This theory, however, ſtands in need of confirmation from other experiments *.

Thirdly, in this ſame column the character of a Volatile Alkali is ſet above that of an Abſorbent Earth, as having a greater affinity with Acids ; and yet theſe Abſorbent Earths decompoſe the Ammoniacal ſalts, drive away the Volatile Alkali from the Acids, and aſſume its place. This is one of the firſt objections made againſt Mr. Geoffroy's Table. His anſwer thereto is printed in the Memoirs of the Academy of Sciences for 1718, where his Table alſo is to be found. We have already declared our opinion about this matter in treating of a Volatile Alkali.

Fourthly, in 1744, Mr. Geoffroy, brother to the author of the Table, who hath done no leſs honour to Chymiſtry than that eminent phyſician, gave in a Memoir containing an exception to the laſt affinity in the firſt column ; namely, that which places Abſorbent Earths above Metallic ſubſtances. He therein ſhews, that Alum may be converted into Copperas by boiling it in iron veſſels ; that, on this occaſion, the iron precipitates the Earth of the Alum, ſeparates it from its Acid, and aſſumes its place ; ſo that of courſe it muſt have a greater affinity, than the Abſorbent Earth of Alum, with the Vitriolic Acid.

At the head of the ſecond column ſtands the character of the Marine Acid, which ſignifies that the affinities of this Acid are the ſubject of the column. Immediately below it is placed the mark of Tin. As this is a metalline ſubſtance, and as the firſt column places metalline ſubſtances in the

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* Mr. Margraaf, an able German Chymiſt, has made ſeveral experiments, which induce him to think that the Acid of Phoſphorus is of a particular kind, and different from that of ſea-ſalt. May it not be the Marine Acid, but altered by the union it has contracted with the Phlogiſton? Or may it not be, with reſpect to Phoſphorus, what the volatile ſulphureous ſpirit is, with reſpect to Sulphur? See the Memoirs of the Royal Academy of Sciences of Berlin.

loweſt degree of affinity with all Acids, it is plain we muſt ſuppoſe Fixed Alkalis, Volatile Alkalis, and Abſorbent Earths, to be placed here in order after the Marine Acid, and before Tin. Tin, then, is of all Metalline ſubſtances that which has the greateſt affinity with the Marine Acid; and then follow Regulus of Antimony, Copper, Silver, Mercury. Gold comes laſt of all; and there are no leſs than two vacant places above it. By this means it is in ſome ſort excluded from the rank of ſubſtances that have an affinity with the Marine Acid. The reaſon thereof is, that this Acid alone is not capable of diſſolving Gold and combining therewith, neceſſarily requiring for that purpoſe the aid of the Nitrous Acid, or at leaſt of the Phlogiſton.

The third column exhibits the affinities of the Nitrous Acid, the character whereof ſtands at its head. Immediately below it is the ſign of Iron, as the metal which has the greateſt affinity with this Acid; and then follow other metals, each according to the degree of its relation; to wit, Copper, Lead, Mercury, and Silver. In this column, as in the preceding one, we muſt ſuppoſe the ſubſtances, which in the firſt column ſtand above Metallic ſubſtances, to be placed in their proper order before Iron.

The fourth column is intended to repreſent the Affinities of the Vitriolic Acid. Here Mr. Geoffroy has placed the Phlogiſton as the ſubſtance which has the greateſt affinity with this Acid, for the reaſon given in our explanation of the firſt column. Below it he has ranked Fixed Alkalis, Volatile Alkalis, and Abſorbent Earths, to ſhew that this is an exception to the firſt column. As to Metalline ſubſtances, he has ſet down but three, being thoſe with which the Vitriolic Acid has the moſt perceptible affinity: theſe metals, placed in the order of their affinities, are Iron, Copper, and Silver.

The fifth column ſhews the affinities of Abſorbent Earths. As theſe Earths have no ſenſible affinity but with Acids, this column contains only the characters of the Acids ranked according to the degree of their ſtrength, or affinity with the Earths; to wit, the Vitriolic, the Nitrous, and the Marine Acids. Underneath this laſt might be placed the Acid of Vinegar, or the Vegetable Acid.

The ſixth column expreſſes the Affinities of Fixed Alkalis with Acids, which are the ſame with thoſe of Abſorbent Earths. Moreover, we find Sulphur placed here below all the Acids; becauſe Liver of Sulphur, which is a combination of Sulphur with a Fixed Alkali, is actually decompounded by any Acid: for any Acid precipitates the Sulphur and unites with the Alkali.

Immediately over the Sulphur, or in the ſame ſquare with it, might be ſet a mark denoting the Volatile Sulphureous Spirit; becauſe, like Sulphur, it has leſs affinity than any other Acid with Fixed Alkalis. Oils might alſo be ranked with Sulphur, becauſe they unite with Fixed Alkalis, and therewith form Soaps, which are decompounded by any Acid whatever.

The ſeventh column points out the affinities of Volatile Alkalis, which are likewiſe the ſame as thoſe of Abſorbent Earths; and the Vegetable Acid might be placed here alſo under the Marine Acid.

The eighth column ſpecifies the affinities of Metallic ſubſtances with Acids. The affinities of the Acids, which, with reſpect to Fixed Alkalis, Volatile Alkalis, and Abſorbent Earths, ſucceeded each other uniformly, do not appear in the ſame order here. The Marine Acid, inſtead of being placed below the Vitriolic and Nitrous Acids, ſtands, on the contrary, at their head; becauſe, in fact, this Acid ſeparates Metalline ſubſtances from all the other Acids with which they happen to be united, and, forcing theſe Acids to quit poſſeſſion, intrudes into their place. Nevertheleſs, this is not a general rule; for ſeveral Metalline ſubſtances muſt be excepted, particularly Iron and Copper.

The ninth column declares the affinities of Sulphur. Fixed Alkalis, Iron, Copper, Lead, Silver, Regulus of Antimony, Mercury, and Gold, ſtand below it in the order of their affinities. With regard to Gold it muſt be obſerved, that it will not unite with pure Sulphur: it ſuffers itſelf to be diſſolved only by the Liver of Sulphur, which is known to be a compoſition of Sulphur and Fixed Alkali.

At the head of the tenth column appears Mercury, and beneath it ſeveral Metalline ſubſtances, in the order of their affinities with it. Thoſe Metalline ſubſtances are Gold, Silver, Lead, Copper, Zinc, and Regulus of Antimony.

It is proper to remark on this column, that Regulus of Antimony, which ſtands the loweſt, unites but very imperfectly with Mercury; and that after a ſeeming union of theſe two Metallic ſubſtances hath been obtained, by a tedious triture with the addition of water, they do not continue long united, but ſpontaneouſly ſeparate from each other in a ſhort time. Iron and Tin are here excluded; the former with great reaſon, becauſe hitherto it hath not been clearly proved, by any known experiment, that ever Mercury was united with Iron: but the ſame objection cannot be made to Tin, which amalgamates very well with Mercury, and might therefore be placed in this column nearly between Lead and Copper. I uſe the word *nearly*, becauſe the different degrees of affinity between Metalline ſubſtances and Mercury are not ſo exactly determined, as the other relations before conſidered; ſeeing they generally unite with it, without excluding one another. We can therefore ſcarce judge of the degree of affinity that belongs to each, but by the greater or leſs readineſs of each to amalgamate therewith.

The eleventh column ſhews, that Lead has a greater affinity with Silver than with Copper.

The twelfth, that Copper has a greater affinity with Mercury than with Calamine.

The thirteenth, that Silver has a greater affinity with Lead than with Copper.

The fourteenth contains the affinities of Iron. Regulus of Antimony ſtands immediately underneath it, as being the Metallic ſubſtance which has the greateſt affinity with it. Silver, Copper, and Lead, are placed together in the next ſquare below, becauſe the degrees of affinity which thoſe metals have with Iron are not exactly determined.

The ſame is to be ſaid of the fifteenth column: Regulus of Antimony ſtands at its head; Iron is immediately below it; and below the Iron the ſame three metals occupy one ſquare as before.

Laſtly, the ſixteenth column indicates that Water has a greater affinity with Spirit of Wine than with Salts. By this general expreſſion muſt not be underſtood any Saline ſubſtance whatever; but only the Neutral Salts, which Spirit of Wine frees from the water that kept them in ſolution. Fixed Alkalis, on the contrary, as well as the Mineral Acids, have a greater affinity than Spirit of Wine with water: ſo that theſe Saline ſubſtances, being well dephlegmated, and mixed with Spirit of Wine, imbibe the water it contains and rectify it.

To theſe might be added another ſhort column, having Spirit of Wine at its head: immediately below it ſhould be the character of Water, and below that the mark of Oil. This column would ſhew that the Spirit of Wine has a greater affinity with Water than with Oils; becauſe any Oily matter whatever, that is diſſolved in Spirit of Wine, may be actually ſeparated from it by the affuſion of Water. This rule admits of no exception but in one caſe; which is when the oily ſubſtance partakes of the nature of ſoap, by having contracted an union with ſome ſaline matter. But as this muſt be imputed wholly to that adventitious ſaline matter being ſuperadded to the oily ſubſtance, it is no juſt foundation for an exception, and the affinity in queſtion is nevertheleſs general.

We have now delivered every thing material that we had to ſay concerning Mr. Geoffroy's Table of Affinities. It is, as we obſerved before, of exceeding great ſervice, as it collects into one view the principal truths laid down in this Treatiſe. Indeed the moſt advantageous way of uſing it is, not to delay conſulting it till you have read the book through, but to turn to it while you are reading, as oft as any affinity between bodies is treated of; which it will imprint more ſtrongly on your mind, by repreſenting it in a manner before your eyes.

CHAP. XVIII.

The THEORY *of* CONSTRUCTING *the* VESSELS *moſt commonly uſed in* CHYMISTRY.

CHYMISTS cannot perform the operations of their art without the help of a conſiderable number of veſſels, inſtruments, and furnaces, adapted to contain the bodies on which they intend to work, and to apply to them the ſeveral degrees of heat required by different proceſſes. It is therefore proper, before we advance to the operations themſelves, to conſider particularly and minutely what relates to the inſtruments with which they are to be performed.

Veſſels intended for Chymical Operations ſhould, to be perfect, be able to bear, without breaking, the ſudden application of great heat and great cold; be impenetrable to every thing, and unalterable by any ſolvent; unvitrifiable, and capable of enduring the moſt violent fire without melting: but hitherto no veſſels have been found with all theſe qualities united.

They are made of ſundry materials; namely, of metal, of glaſs, and of earth. Metalline veſſels, eſpecially thoſe made of Iron or Copper, are apt to be corroded by almoſt every ſaline, oily, or even aqueous ſubſtance. For this reaſon, in order to render the uſe of them a little more extenſive, they are tinned on the inſide. But, notwithſtanding this precaution, they are on many occaſions not to be truſted; and ſhould never be employed in any nice operations which require great accuracy: they are, moreover, incapable of reſiſting the force of fire.

Earthen veſſels are of ſeveral ſorts. Some, that are made of a refractory earth, are capable of being ſuddenly expoſed to a ſtrong fire without breaking, and even of ſuſtaining a great degree of heat for a conſiderable time: but they generally ſuffer the vapours of the matters which they contain, as well as vitrified metals, to paſs through them, eſpecially the glaſs of lead, which eaſily penetrates them and runs through their pores as through a ſieve. There are others made of an earth that, when well baked, looks as if it were half vitrified: theſe being much leſs porous, are capable of retaining the vapours of the matters which they contain, and even glaſs of lead in fuſion; which is one of the ſevereſt trials a veſſel can be put to: but then they are more brittle than the other ſort.

Good glaſs veſſels ſhould conſtantly be employed in preference to all others, whenever they can poſſibly be uſed: and that not only becauſe they are no way injured by the moſt active ſolvents, nor ſuffer any part of what they contain to paſs through, but alſo becauſe their tranſparency allows the Chymiſt to obſerve what paſſes within them: which is always both curious and uſeful. But it is pity that veſſels of this ſort ſhould not be able to endure a fierce fire without melting. We ſhall take care, when we come to deſcribe the ſeveral ſorts of chymical inſtruments, and the manner of uſing them, to note what veſſels are to be preferred to others on different occaſions.

Diſtillation, as hath been already ſaid, is an operation by which we ſeparate from a body, by the help of a gradual heat, the ſeveral principles of which it conſiſts.

There are three methods of diſtilling. The firſt is performed by applying the heat over the body whoſe principles are to be extracted. In this caſe, as the liquors, when heated and converted into vapours, conſtantly endeavour to fly from the center of heat, they are forced to re-unite in the lower part of the veſſel, that contains the matter in diſtillation, and ſo paſſing through the pores or holes of that veſſel, they fall into another cold veſſel applied underneath to receive them. This way of diſtilling is on this account called diſtilling *per Deſcenſum*. It requires no other apparatus than two veſſels figured like ſegments of hollow ſpheres, whereof that which is pierced with little holes, and intended to contain the matter to be diſtilled, ſhould be much leſs than the other, which is to contain the fire, and to fill its aperture exactly; the whole together to be ſupported vertically upon a third veſſel, which is to ſerve the purpoſe of a recipient, admitting into its mouth the convex bottom of the veſſel containing the matter to be diſtilled, which muſt accurately fill it. This method of diſtilling is but little uſed.

The ſecond method of diſtilling is performed by applying the heat underneath the matter to be decompoſed. On this occaſion the liquors being heated, rarefied, and converted into vapours, riſe, and are condenſed in a veſſel contrived for that purpoſe, which we ſhall preſently deſcribe. This way of diſtilling is called diſtilling *per Aſcenſum*, and is much uſed.

The veſſel in which this diſtillation *per Aſcenſum* is performed we call an *Alembic*.

There are ſeveral ſorts thereof, differing from one another both in the matter of which, and the manner in which, they are made.

Thoſe employed to draw the odoriferous waters and eſſential oils of plants are generally made of copper, and conſiſt of ſeveral pieces. The firſt, which is deſigned to contain the plant, is formed nearly like a hollow cone, the vertex whereof is drawn out in the ſhape of a hollow cylinder or tube: this part is named the *Cucurbit*, and its tube the *Neck* of the *Alembic*. To the upper end of this tube another veſſel is ſoldered: this is called the *Head*, and commonly has likewiſe the form of a cone, joined to the neck of the alembic by its baſe, round which, on the inſide, is hollowed a ſmall groove, communicating with an orifice that opens at its moſt depending part. To this orifice is ſoldered a ſmall pipe in a direction ſloping downwards, which is called the *Noſe*, *Spout*, or *Beak* of the alembic.

As ſoon as the matters contained in the alembic grow hot, vapours begin to ariſe from them, and aſcending through the neck of the alembic into the head, are by the ſides thereof ſtopped and condenſed: from thence they trickle down in little ſtreams to the groove, which conveys them to the ſpout; and by that they paſs out of the alembic into a glaſs veſſel with a long neck, the end of the ſpout being introduced into that neck, and luted thereto.

To facilitate the refrigeration and condenſation of the vapours circulating in the head, all alembics of metal are moreover provided with another piece, which is a kind of large pan of the ſame metal, fitted and ſoldered round the head.

This piece ſerves to keep cold water in, which inceſſantly cools the head, and therefore it is called the *Refrigeratory*. The water in the refrigeratory itſelf grows hot after ſome time, and muſt therefore be changed occaſionally; the heated water being firſt drawn off by means of a cock fixed near the bottom of the refrigeratory. All copper alembics ſhould be tinned on the inſide for the reaſons already given.

When ſaline ſpirits are to be diſtilled, alembics of metal muſt not be uſed; becauſe the ſaline vapours would corrode them. In this caſe recourſe muſt be had to alembics of glaſs. Theſe conſiſt of two pieces only; namely, a *Cucurbit*, whoſe ſuperior orifice is admitted into and exactly luted with its *Head*, which is the ſecond piece.

In general, as alembics require that the vapours of the matter to be diſtilled ſhould riſe to a conſiderable heighth, they ought to be uſed only when the moſt volatile principles are to be drawn from bodies: and the lighter and more volatile the ſubſtances to be ſeparated by diſtillation are, the taller muſt the alembic be; becauſe the moſt ponderous parts, being unable to riſe above a certain heighth, fall back again into the cucurbit as ſoon as they arrive there, leaving the lighter to mount alone, whoſe volatility qualifies them to aſcend into the head.

When a matter is to be diſtilled, that requires a very tall alembic, and yet does not admit of a metalline veſſel, the end will be beſt anſwered by a glaſs veſſel of a round or oval ſhape, having a very long neck, with a ſmall head fitted to its extremity. Such a veſſel ſerves many purpoſes: it is ſometimes employed as a receiver, and at other times as a digeſting veſſel; on which laſt occaſion it goes under the name of a *Matraſs*. When one of theſe, provided with a head, is applied to the purpoſe of diſtilling, it forms a ſort of alembic.

There are ſome alembics of glaſs, blown in ſuch a manner by the workmen, that the body and head form but one continued piece. As theſe alembics do not ſtand in need of having their ſeveral pieces luted together, they are very uſeful on ſome occaſions, when ſuch exceeding ſubtile vapours riſe as are capable of tranſpiring through lutes. The head muſt have an aperture at the top, provided with a ſhort tube, through which, by means of a funnel with a long pipe, the matter to be diſtilled may be introduced into the cucurbit. This is to be exactly cloſed with a glaſs ſtopple, the ſurface whereof muſt be made to fit the inſide of the tube in every point, by rubbing thoſe two pieces well together with emery.

Another ſort of alembic hath alſo been invented, which may be uſed with advantage when *Cohobation* is required; that is, when the liquor obtained by diſtillation is to be returned upon the matter in the cucurbit; and eſpecially when it is intended that this cohobation ſhall be repeated a great number of times. The veſſel we are ſpeaking of is conſtructed exactly in the ſame manner as that laſt deſcribed; except that its beak, inſtead of being in a ſtraight line, as in the other alembics, forms a circular arch, and re-enters the cavity of the cucurbit, in order to convey back again the liquor collected in the head. This inſtrument hath commonly two beaks oppoſite to each other, both turned in this manner, and is called a *Pelican:* it ſaves the artiſt the trouble of frequently unluting and reluting his veſſels, as well as the loſs of a great many vapours.

There are certain ſubſtances which in diſtillation afford matters in a concrete form, or riſe wholly in the form of a very light powder, called *Flowers*. When ſuch ſubſtances are to be diſtilled, the cucurbit which contains them is covered with a head without a noſe, which is named a *Blind-head*.

When the flowers riſe in great quantities and very high, a number of heads is employed to collect them; or rather a number of a kind of pots, conſiſting of a body only without any bottom, which fitting one into the other form a canal, that may be lengthened or ſhortened at pleaſure, according as the flowers to be ſublimed are more or leſs volatile. The laſt of the heads, which terminates the canal, is quite cloſe at one end, and makes a true blind-head These veſſels are called *Aludels;* they are uſually of earthen or ſtone ware.

All the veſſels above-mentioned are fit only for diſtilling ſuch light volatile matters as can be eaſily raiſed and brought over; ſuch as phlegm, eſſential oils, fragrant waters, acid oily ſpirits, volatile alkalis, *&c.* But when the point is to procure by diſtillation principles that are much leſs volatile, and incapable of riſing high, ſuch as the thick fetid oils, the vitriolic, the nitrous, and the marine acids, *&c.* we are under a neceſſity of having recourſe to other veſſels, and another manner of diſtilling.

It is eaſy to imagine, that ſuch a veſſel muſt be much lower than the alembic. It is indeed no more than a hollow globe, whoſe upper part degenerates into a neck or tube, that is bent into a horizontal poſition; for which reaſon this inſtrument is called a *Retort:* it is always of one ſingle piece.

The matter to be diſtilled is introduced into the body of the retort by means of a ladle with a long tubular ſhank. Then it is ſet in a furnace built purpoſely for this uſe, and ſo that the neck of the retort coming out of the furnace may, like the noſe of the alembic, ſtand in a ſloping poſition, to facilitate the egreſs of the liquors, which by its means are conveyed to a receiver, into which it is introduced, and with which it is luted. This way of diſtilling, in which the vapours ſeem rather to be driven out of the veſſel horizontally and laterally, than raiſed up and ſublimed, is for that reaſon called Diſtillation *per Latus*.

Retorts are, of all the inſtruments of diſtillation, thoſe that muſt ſuſtain the greateſt heat, and reſiſt the ſtrongeſt ſolvents; and therefore they muſt not be made of metal. Some, however, which are made of iron may do well enough on certain occaſions: the reſt are either of glaſs or earth. Thoſe of glaſs, for the reaſons above given, are preferable to the other ſort, in all caſes where they are not to be expoſed to ſuch a force of fire as may melt them. The beſt glaſs, that which ſtands both heat and ſolvents beſt, is that in which there are feweſt alkaline ſalts. Of this ſort is the green German glaſs: the beautiful white cryſtal glaſs is far from being equally ſerviceable.

Retorts, as well as alembics, may be of different forms. For example, ſome matters are apt to ſwell, and riſe over the neck of the retort in ſubſtance, without ſuffering any decompoſition; when ſuch matters are to be diſtilled in a retort, it is proper that the body of the veſſel, inſtead of being globular, be drawn out into the form of a pear, ſo as nearly to reſemble that of a cucurbit. In a retort of this kind, the diſtance between the bottom and the neck being much greater than in thoſe whoſe bodies are ſpherical, the matters contained have much more room for expanſion; ſo that the inconvenience here mentioned is thereby prevented. Retorts of this form are called Engliſh retorts. As they hold the middle place between alembics and common retorts, they may be uſed to diſtil ſuch matters as have a mean degree of volatility between the greateſt and the leaſt.

It is moreover proper to have, in a laboratory, ſundry retorts with necks of different diameters. Wide necks will be found the fitteſt for conveying thick matters, and ſuch as readily become fixed; for inſtance, ſome very thick fetid oils, butter of antimony, *&c.*; for as theſe matters acquire a conſiſtence as ſoon as they are out of the reach of a certain degree of heat, they would ſoon choak a narrow neck, and by ſtopping the vapours which riſe at the ſame time from the retort, might occaſion the burſting of the veſſels.

Some retorts are alſo made with an opening on their upper ſide, like that of tubulated glaſs alembics, which is to be cloſed in the ſame manner with a glaſs ſtopple. Theſe retorts are alſo called Tubulated retorts, and ought always to be uſed whenever it is neceſſary to introduce freſh matter into the retort during the operation; ſeeing it may be done by means of this invention, without unluting and reluting the veſſels; which ought always to be avoided as much as poſſible.

One of the things that moſt perplexes the Chymiſts, is the prodigious elaſticity of many different vapours, which are frequently diſcharged with impetuoſity during the diſtillation, and are even capable of burſting the veſſels with exploſion, and with danger to the artiſt. On ſuch occaſions it is abſolutely neceſſary to give theſe vapours vent, as we ſhall direct in its proper place: but as that can never be done without loſing a great many of them; as ſome of them in particular are ſo elaſtic that ſcarce any at all would remain in the veſſel; for inſtance, thoſe of the ſpirit of nitre, and eſpecially thoſe of the ſmoking ſpirit of ſalt; the practice is to make uſe of very large receivers, of about eighteen or twenty inches diameter, that the vapours may have ſufficient room to circulate in, and by applying to the wide ſurface preſented them by the extenſive inſide of ſuch a large veſſel, may be condenſed into drops. Theſe huge receivers are commonly in the form of hollow globes, and are called Ballons.

To give theſe vapours ſtill more room, ballons have been contrived with two open gullets in each, diametrically oppoſite to one another; whereof one admits the neck of the retort, and the other is received by one of the gullets of a ſecond ballon of the ſame form, which is joined in like manner to a third, and ſo on. By this artifice the ſpace may be enlarged at pleaſure. Theſe ballons with two necks are called Adopters.

Operations on bodies that are abſolutely fixed, as metals, ſtones, ſand, *&c.* require only ſuch veſſels as are capable of containing thoſe bodies, and reſiſting the force of fire. Theſe veſſels are little hollow pots, of different dimenſions, which are called Crucibles. Crucibles can hardly be made of any thing but earth; they ought to have a cover of the ſame material fitted to ſhut them cloſe. The beſt earth we know is that whereof thoſe pots are made in which butter is brought from Bretagne: theſe pots themſelves are exceeding good crucibles; and they are almoſt the only ones that are capable of holding glaſs of lead in fuſion, without being penetrated by it.

For the roaſting of ores, that is, freeing them, by the help of fire, from their ſulphureous and arſenical parts, little cups of the ſame material with crucibles are uſed; but they are made flat, ſhallow, and wider above than below, that theſe volatile matters may the more freely exhale. Theſe veſſels are called Teſts, or Scorifiers: they are ſcarce ever uſed but in the Docimaſtic art, that is, in making ſmall Aſſays of ores.

CHAP. XIX.

The THEORY *of* CONSTRUCTING *the* FURNACES *moſt commonly uſed in* CHYMISTRY.

SKILL in conducting and applying fire properly, and determining its different degrees, is of very great conſequence to the ſucceſs of Chymical operations.

As it is exceeding difficult to govern and moderate the action of fire, when the veſſels in which any operation is performed are immediately expoſed to it, Chymiſts have contrived to convey heat to their veſſels, in nice operations, through different mediums, which they place occaſionally between thoſe veſſels and the fire.

Thoſe intermediate ſubſtances in which they plunge their veſſels are called Baths. They are either fluid or ſolid: the fluid baths are water or its vapours. When the diſtilling veſſel is ſet in water, the bath is called *Balneum Mariæ*, or the *Water Bath;* and the greateſt degree of heat of which it is ſuſceptible is that of boiling water. When the veſſel is expoſed only to the vapours which exhale from water, this forms the *Vapour Bath;* the heat of which is nearly the ſame with that of the *Balneum Mariæ*. Theſe baths are uſeful for diſtilling eſſential oils, ardent ſpirits, ſweet-ſcented waters; in a word, all ſuch ſubſtances as cannot bear a greater heat, without prejudice either to their odour, or to ſome of their other qualities.

Baths may alſo be made of any other fluids, ſuch as oils, mercury, *&c.* which are capable of receiving and communicating much more heat: but they are very ſeldom uſed. When a more conſiderable degree of heat is required, a bath is prepared of any ſolid matter reduced to a fine powder, ſuch as ſand, aſhes, filings of iron, *&c.* The heat of theſe baths may be puſhed ſo far as to make the bottom of the veſſel become faintly red. By plunging a thermometer into the bath, by the ſide of the veſſel, it is eaſy to obſerve the preciſe degree of heat applied to the ſubſtance on which you are working. It is neceſſary that the thermometers employed on this occaſion be conſtructed on good principles, and ſo contrived as to be eaſily compared with thoſe of the moſt celebrated natural philoſophers. Thoſe of the illuſtrious Reaumur are moſt uſed and beſt known, ſo that it would not be amiſs to give them the preference. When a greater heat is required than any of thoſe baths can give, the veſſels muſt be ſet immediately on live coals, or in a flaming fire: this is called working with a naked fire; and, in this caſe it is much more difficult than in the other to determine the degrees of heat.

There are ſeveral ways of applying a naked fire. When the heat or flame is reflected upon the upper part of a veſſel which is expoſed to the fire, this is called a Reverberated heat. A Melting heat is that which is ſtrong enough to fuſe moſt bodies. A Forging heat is that of a fire which is forcibly excited by the conſtant blaſt of a pair of bellows, or more.

There is alſo another ſort of fire which ſerves very commodiouſly for may operations, becauſe it does not require to be fed or frequently mended: this is afforded by a lamp with one or more wicks, and may be called a Lamp-heat. It is ſcarce ever employed but to heat baths, in operations which require a gentle and long continued warmth: if it hath any fault, it is that of growing gradually hotter.

All the different ways of applying fire require Furnaces of different conſtructions: we ſhall therefore deſcribe ſuch as are of principal and moſt neceſſary uſe.

Furnaces muſt be divided into different parts or ſtories, each of which has its particular uſe and name.

The lower part of the furnace, deſigned for receiving the aſhes and giving paſſage to the air, is called the Aſh-hole. The aſh-hole is terminated above by a grate, the uſe of which is to ſupport the coals and wood, which are to be burnt thereon: this part is called the Fire-place. The fire-place is in like manner terminated above by ſeveral iron bars, which lie quite a-croſs it from right to left, in lines parellel to each other: the uſe of theſe bars is to ſuſtain the veſſels in which the operations are to be performed. The ſpace above theſe bars to the top of the furnace is the upper ſtory, and may be called the Laboratory of the furnace. Laſtly, ſome furnaces are quite covered above by means of a kind of vaulted roof called the Dome.

Furnaces have moreover ſeveral apertures: one of theſe is at the aſh-hole, which gives paſſage to the air, and through which the aſhes that fall through the grate are raked out; this aperture is called the aſh-hole Door: another is at the fire-place, through which the fire is ſupplied with fuel, as occaſion requires; this is called the mouth or door of the Fire-place, or the Stoke-hole: there is a third in the upper ſtory, through which the neck of the veſſel paſſes; and a fourth in the dome for carrying off the fuliginoſities of combuſtible matters, which is called the Chimney.

To conclude, there are ſeveral other openings in the ſeveral parts of the furnace, the uſe whereof is to admit the air into thoſe places, and alſo, as they can be eaſily ſhut, to incite or ſlacken the activity of the fire, and ſo to regulate it; which has procured them the title of Regiſters. All the other openings of the furnace ſhould be made to ſhut very cloſe, the better to aſſiſt in governing the fire; by which means they likewiſe do the office of regiſters.

In order to our forming a juſt and general idea of the conſtruction of furnaces, and of the diſpoſition of the ſeveral apertures in them, with a view to increaſe or diminiſh the activity of the fire, it will be proper to lay down, as our ground-work, certain principles of natural philoſophy, the truth of which is demonſtrated by experience.

And firſt, every body knows that combuſtible matters will not burn or conſume unleſs they have a free communication with the air; inſomuch that if they be deprived thereof, even when burning moſt rapidly, they will be extinguiſhed at once: that conſequently combuſtion is greatly promoted by the frequent acceſſion of freſh air, and that a ſtream of air, directed ſo as to paſs with impetuoſity through burning fuel, excites the fire to the greateſt poſſible activity.

Secondly, it is certain that the air which touches, or comes near ignited bodies is heated, rarefied, and rendered lighter than the air about it, that is, farther diſtant from the center of heat; and conſequently that this air, ſo heated and become lighter, is neceſſarily determined thereby to aſcend and mount aloft, in order to make room for that which is leſs heated and not ſo light, which by its weight and elaſticity tends to occupy the place quitted by the other. Another conſequence hereof is, that if fire be kindled in a place encloſed every where but above and below, a current of air will be formed in that place, running in a direction from the bottom to the top; ſo that if any light bodies be applied to the opening below, they will be carried up towards the fire; but, on the contrary, if they be held at the opening above, they will be impelled by a force which will drive them up, and carry them away from the fire.

Thirdly and laſtly, it is a truth demonſtrated in hydraulics, that the velocity of a given quantity of any fluid, determined to flow in any direction whatever, is ſo much the greater the narrower the channel is to which that fluid is confined; and conſequently that the velocity of a fluid will be increaſed by making it run from a wider through a narrower paſſage.

Theſe principles being eſtabliſhed, it is eaſy to apply them to the conſtruction of furnaces. Firſt, if a fire be kindled in the fire-place of a furnace, which is open on all ſides, it burns nearly as if it were in the open air. It has with the ſurrounding air a free communication; ſo that freſh air is continually admitted to facilitate the entire combuſtion of the inflammable matters employed as fuel. But there being nothing to determine that air to paſs with rapidity through the fire in this caſe, it does not at all augment the activity thereof, but ſuffers it to waſte away quietly.

Secondly, if the aſh-hole or dome of a furnace, in which a fire is burning, be ſhut quite cloſe, then there is no longer any free communication between the air and the fire: if the aſh-hole be ſhut, the air is debarred from having free acceſs to the fire; if the dome be ſtopt, the egreſs of the air rarefied by the fire is prevented; and conſequently the fire muſt in either caſe burn very faintly and ſlowly, gradually die away, and at laſt go quite out.

Thirdly, if all the openings of the furnace be wholly cloſed, it is evident that the fire will be very quickly extinguiſhed.

Fourthly, if only the lateral openings of the fire-place be ſhut, leaving the aſh-hole and upper part of the furnace open; it is plain that the air entering by the aſh-hole will neceſſarily be determined to go out at top, and that conſequently a current of air will be formed, which will paſs through the fire, and make it burn briſkly and vigorouſly.

Fifthly, if both the aſh-hole and the upper ſtory of the furnace be of ſome length, and form canals either cylindric or priſmatic, then the air being kept in the ſame direction through a longer ſpace, the courſe of its ſtream will be both ſtronger and better determined, and conſequently the fire will be more animated by it.

Sixthly and laſtly, if the aſh-hole and the upper part of the furnace, inſtead of being cylindric or priſmatic canals, have the form of truncated cones or pyramids, ſtanding on their baſes, and ſo ordered that the upper opening of the aſh-hole, adjoining to the fire-place, may be wider than the baſe of the ſuperiour cone or pyramid, then the ſtream of air, being forced to paſs inceſſantly from a larger channel through a ſmaller, muſt be conſiderably accelerated, and procure to the fire the greateſt activity which it can receive from the make of a furnace.

The materials fitteſt for building furnaces are, 1. Bricks, joined together with potters clay mixed with ſand and moiſtened with water. 2. Potters clay mingled with potſherds, moiſtened with water, and baked in a violent fire. 3. Iron; of which all furnaces may be made, with this precaution, that the inſide be provided with a great many prominent points, as faſtenings for a coat of earth, with which the internal parts of the furnace muſt neceſſarily be covered to defend it from the action of the fire.

The reverberating furnace is one of thoſe that are moſt employed in Chymiſtry: it is proper for diſtillations by the retort, and ſhould be conſtructed in the following manner.

Firſt, the uſe of the aſh-hole being, as was ſaid, to give paſſage to the air and to receive the aſhes, no bad conſequence can attend its being made pretty high: it may have from twelve to twenty or twenty-four inches in heighth. Its aperture ſhould be wide enough to admit billets of wood, when a great fire is to be made.

Secondly, the aſh-hole muſt be terminated at its upper part by an iron grate, the bars of which ſhould be very ſubſtantial, that they may reſiſt the action of the fire: this grate is the bottom of the fire-place, and deſtined to ſupport the coals. In the lateral part of the fire-place, and nearly about the ſame heighth with the grate, there ſhould be a hole of ſuch a ſize that it may eaſily admit charcoal, as well as little tongs and ſhovels for managing the fire. This aperture or mouth of the fire-place ſhould be perpendicularly over the mouth of the aſh-hole.

Thirdly, from ſix to eight or ten inches high above the grate over the aſh-hole, little apertures muſt be made in the walls of the furnace, of eight or ten lines in diameter, an inch from one another, and thoſe in one ſide muſt be diametrically oppoſite to thoſe in the other. The uſe of theſe holes is to receive bars of iron for the retort to reſt on; which ſhould be, as I ſaid, at different heights, in order to accommodate retorts of different ſizes. At the upper extremity of this part of the furnace, which reaches from the iron bars to the top, the heighth whereof ſhould be ſomewhat leſs than the width of the furnace, muſt be cut a ſemi-circular aperture for the neck of the retort to come through. This hole muſt by no means be over the doors of the fire-place and aſh-hole; for then, as it gives paſſage to the neck of the retort, it muſt of courſe be oppoſite to the receiver, and in that caſe the receiver itſelf would ſtand over againſt thoſe two apertures; which would be attended with this double inconvenience, that the receiver would not only grow very hot, but greatly embarraſs the operator, whoſe free acceſs to the fire-place and aſh-hole would be thereby obſtructed. It is proper therefore that the ſemi-circular cut we are ſpeaking of be ſo placed that when the greateſt ballons are luted to the retort they may leave an open paſſage to the fire-place and aſh-hole.

Fourthly, in order to cover in the laboratory of the reverberating furnace, there muſt be a roof made for it in the form of a cupola, or concave hemiſphere, having the ſame diameter as the furnace. This dome ſhould have a ſemi-circular cut in its rim, anſwering to that above-directed to be made in the upper extremity of the furnace, ſo that, when adjuſted to each other, the two together may form a circular hole for the neck of the retort to paſs through. At the top of this dome there muſt alſo be a circular hole of three or four inches diameter, carrying a ſhort tapering funnel of the ſame diameter, and three inches high, which will ſerve for a chimney to carry off all fuliginoſities, and accelerate the current of the air. This paſſage may be ſhut at pleaſure with a flat cover. Moreover, as it is neceſſary that the dome ſhould be taken off and put on with eaſe, it ſhould have two ears or handles for that purpoſe: a portative or moveable furnace ſhould alſo have a pair of handles, fixed oppoſite to each other, between the aſh-hole and the fire-place.

Sixthly and laſtly, a conical canal muſt be provided of about three feet long, and ſufficiently wide at its lower end to admit the funnel of the aperture at the top of the dome. This conical tube is to be applied to the dome when the fire is required to be extremely active: it tapers gradually from its baſe upwards, and breaks off as if truncated at top, where it ſhould be about two inches wide.

Beſides the apertures already mentioned as neceſſary to a reverberating furnace, there muſt alſo be many other ſmaller holes made in its aſh-hole, fire-place, laboratory, and dome, which muſt all be ſo contrived as to be eaſily opened and ſhut with ſtopples of earth: theſe holes are the regiſters of the furnace, and ſerve to regulate the activity of the fire, according to the principles before laid down.

When the action of the fire is required to be exactly uniform and very briſk, it is neceſſary to ſtop carefully with moiſt earth all the little chinks in the juncture of the dome with the furnace, between the neck of the retort and the circular hole through which it paſſes, and which it never fills exactly, and, laſtly, the holes which receive the iron bars that ſuſtain the retort.

It is proper to have, in a laboratory, ſeveral reverberating furnaces of different magnitudes; becauſe, they muſt be proportioned to the ſize of the retorts employed. The retort ought to fill the furnace, ſo as to leave only the diſtance of an inch between it and the inſide of the furnace.

Yet when the retort is to be expoſed to a moſt violent fire, and eſpecially when it is required that the heat ſhall act with equal force on all parts of the furnace, and as ſtrongly on its vault as on its bottom, a greater diſtance muſt be left between the retort and the inſide of the furnace; for then the furnace may be filled with coals, even to the upper part of the dome. If moreover ſome pieces of wood be put into the aſh-hole, the conical canal fitted on to the funnel of the dome, and all the apertures of the furnace exactly cloſed, except the aſh-hole and the chimney, the greateſt heat will then be excited that this furnace can produce.

The furnace now deſcribed may alſo be employed in many other chymical operations. If the dome be laid aſide, an alembic may very well be placed therein: but then the ſpace, which will be left between the body of the alembic and the top of the upper part of the furnace, muſt be carefully filled up with Windſor-loam moiſtened; for without that precaution the heat will ſoon reach the very head, which ought to be kept as cool as poſſible, in order to promote the condenſation of the vapours. On this occaſion therefore it will be proper to leave no holes open in the fire-place, but the lateral ones; of which alſo thoſe over-againſt the receiver muſt be ſtopped.

A pot, or broad-brimmed earthen pan, may be placed over this furnace, and being ſo fitted to it as to cloſe the upper part thereof accurately, and filled with ſand, may ſerve for a ſand-heat to diſtil with.

The bars deſigned to ſupport diſtilling veſſels being taken out, a crucible may ſtand therein, and many operations be performed that do not require the utmoſt violence of fire. In a word, this furnace is one of the moſt commodious that can be, and more extenſively uſeful than any other.

The Melting furnace is deſigned for applying the greateſt force of heat to the moſt fixed bodies, ſuch as metals and earths. It is never employed in diſtilling: it is of no uſe but for calcination and fuſion; and conſequently need not admit any veſſels but crucibles.

The aſh-hole of this furnace differs from that of the reverberating furnace only in this, that it muſt be higher, in order to raiſe the fire-place to a level with the artiſt's hand; becauſe in that all the operations of this furnace are performed. The aſh-hole therefore muſt be about three feet high: and this heighth procures it moreover the advantage of a good draught of air. For the ſame reaſon, and in conſequence of the principles we laid down, it ſhould be ſo built that its width leſſening inſenſibly from the bottom to the top, it may be narrower where it opens into the fire-place than any where below.

The aſh-hole is terminated at its upper end, like that of the reverberating furnace, by a grate, which ſerves for the bottom of the fire-place, and ought to be very ſubſtantial, that it may reſiſt the violence of the fire. The inſide of this furnace is commonly an elliptic curve; becauſe it is demonſtrated by mathematicians that ſurfaces having that curvature reflect the rays of the ſun, or of fire, in ſuch a manner, that meeting in a point, or a line, they produce there a violent heat. But, to anſwer this purpoſe, thoſe ſurfaces muſt be finely poliſhed; an advantage hardly procurable to the internal ſurface of this furnace, which can be made of nothing but earth: beſides, if it were poſſible to give it a poliſh, the violent action of the fire that muſt be employed in this furnace would preſently deſtroy it. Yet the elliptical figure muſt not be entirely diſregarded: for, if care be taken to keep the internal ſurface of the furnace as ſmooth as poſſible, it will certainly reflect the heat pretty ſtrongly, and collect it about the center.

The fire-place of this furnace ought to have but four apertures.

Firſt, that of the lower grate, which communicates with the aſh-hole.

Secondly, a door in its fore-ſide, through which may be introduced coals, crucibles, and tongs for managing them: this aperture ſhould be made to ſhut exactly with a plate of iron, having its inſide coated with earth, and turning on two hinges fixed to the furnace.

Thirdly, over this door a hole ſlanting downwards, towards the place where the crucible is to ſtand. The uſe of this hole is to give the operator an opportunity of examining the condition of the matters contained in his crucible without opening the door of the fire-place: this hole ſhould be made to open and ſhut eaſily, by means of a ſtopple of earth.

Fourthly, a circular aperture of about three inches wide in the upper part or vault of the furnace, which ſhould gradually leſſen and terminate, like that of the dome of the reverberating furnace, in a ſhort conical funnel of about three inches long, and fitted to enter the conical pipe before deſcribed, which is applied when the activity of the fire is to be increaſed.

When this furnace is to be uſed, and a crucible to be placed in it, care muſt be taken to ſet on the grate a cake of baked earth, ſomewhat broader than the foot of the crucible. The uſe of this ſtand is to ſupport the crucible, and raiſe it above the grate, for which purpoſe it ſhould be two inches thick. Were it not for this precaution the bottom of the crucible, which would ſtand immediately on the grate, could never be thoroughly heated, becauſe it would be always expoſed to the ſtream of cold air which enters by the aſh-hole. Care ſhould alſo be taken to heat this earthen bottom red-hot before it be placed in the furnace, in order to free it from any humidity, which might otherwiſe happen to be driven againſt the crucible during the operation, and occaſion its breaking.

We omitted to take notice, in ſpeaking of the aſh-hole, that, beſides its door, it ſhould have about the middle of its heighth a ſmall hole, capable of receiving the noſel of a good perpetual bellows, which is to be introduced into it and worked, after the door is exactly ſhut, when it is thought proper to excite the activity of the fire to the utmoſt violence.

The Forge is only a maſs of bricks of about three feet high, along whoſe upper ſurface is directed the noſe or pipe of a pair of large perpetual bellows, ſo placed that the operator may eaſily blow the fire with one hand. The coals are laid on the hearth of the forge near the noſe of the bellows; they are confined, if neceſſary, to prevent their being carried away by the wind of the bellows, within a ſpace incloſed by bricks; and then by pulling the bellows the fire is continually kept up in its greateſt activity. The forge is of uſe when there is occaſion to apply a great degree of heat ſuddenly to any ſubſtance, or when it is neceſſary that the operator be at liberty to handle frequently the matters which he propoſes to fuſe or calcine.

The Cupelling furnace is that in which gold and ſilver are purified, by the means of lead, from all alloy of other metallic ſubſtances. This furnace muſt give a heat ſtrong enough to vitrify lead, and therewith all the alloy which the perfect metals may contain. This furnace is to be built in the following manner.

Firſt, of thick iron plates, or of ſome ſuch compoſition of earth as we recommended for the conſtruction of furnaces, muſt be formed a hollow quadrandgular priſm, whoſe ſides may be about a foot broad, and from ten to eleven inches high; and extending from thence upwards may converge towards the top, ſo as to form a pyramid truncated at the heighth of ſeven or eight inches, and terminated by an aperture of the width of ſeven or eight inches every way. The lower part of the priſm is terminated, and cloſed, by a plate of the ſame materials of which the furnace is conſtructed.

Secondly, in the fore-ſide or front of this priſm there is an opening of three or four inches in heighth, by five or ſix inches in breadth: this opening, which ſhould be very near the bottom, is the door of the aſh-hole. Immediately over this opening is placed an iron grate, the bars of which are quadrangular priſms of half an inch ſquare, laid parallel to each other, and about eight or nine inches aſunder, and ſo diſpoſed that two of their angles are laterally oppoſite, the two others looking one directly upwards and the other downwards. As in this ſituation the bars of the grate preſent to the fire-place very oblique ſurfaces, the aſhes and very ſmall coals do not accumulate between them, or hinder the free entrance of the air from the aſh-hole. This grate terminates the aſh-hole at its upper part, and ſerves for the bottom of the fire-place.

Thirdly, three inches, or three and a half, above the grate, there is in the fore-ſide of the furnace another opening, terminated by an arch for its upper part, which conſequently has the figure of a ſemi-circle: it ought to be four inches wide at bottom, and three inches and an half high at its middle. This opening is the door of the fire-place; yet it is not intended for the ſame uſes as the door of the fire-place in other furnaces: the purpoſe for which it is actually deſtined ſhall be explained when we come to ſhew how the furnace is to be uſed. An inch above the door of the fire-place, ſtill in the fore-ſide of the furnace, are two holes of about an inch diameter, and at the diſtance of three inches and a half from each other, to which anſwer two other holes of the ſame ſize, made in the hinder part, directly oppoſite to theſe. There is, moreover, a fifth hole of the ſame width about an inch above the door of the fire-place. The deſign of all theſe holes ſhall be explained when we deſcribe the manner in which theſe furnaces are to be uſed.

Fourthly, the fore-part of the furnace is bound by three iron braces, one of which is fixed juſt below the door of the aſh-hole; the ſecond occupies the whole ſpace between the aſh-hole door and the door of the fire-place, and has two holes in it, anſwering to thoſe which we directed to be made in the furnace itſelf about this place; and the third is placed immediately over the door of the fire-place. Theſe braces muſt extend from one corner of the front of the furnace to the other, and be faſtened thereto with iron pins, in ſuch a manner that their ſides next to the doors may not lie quite cloſe to the body of the furnace, but form a kind of grooves for the iron plates to ſlide in, that are deſigned to ſhut the two doors of the furnace when it is neceſſary. Each of theſe iron plates ſhould have a handle, by which it may be conveniently moved; and to each door there ſhould be two plates, which meeting each other, and joining exactly in the middle of the door-place, may ſhut it very cloſe. Each of the two plates belonging to the door of the fire-place ought to have a hole in its upper part; one of theſe holes ſhould be a ſlit of about two lines wide, and half an inch long; the other may be a ſemi-circular opening of one inch in heighth and two in breadth. Theſe holes ſhould be placed ſo that neither of them may open into the fire-place when the two plates are joined together in the middle of the door to ſhut it cloſe.

Fifthly, to terminate the furnace above, there muſt be a pyramid formed of the ſame materials with the furnace, hollow, quadrangular, three inches high on a baſe of ſeven inches, which baſe muſt exactly fit the upper opening of the furnace: the top of this pyramidal cover muſt end in a tube of three inches in diameter and two in heighth, which muſt be almoſt cylindrical, and yet a little inclining to the conical form. This tube ſerves, as in the furnaces already deſcribed, to carry the conical funnel, which is fitted to the upper part when a fire of extraordinary activity is wanted.

The furnace thus conſtructed is fit to ſerve all the purpoſes for which it is deſigned: yet before it can be uſed another piece muſt be provided, which, though it does not properly belong to the furnace, is nevertheleſs neceſſary in all the operations performed by it; and that is a piece contrived to contain the cupels, or other veſſels which are to be expoſed to the fire in this furnace. It is called a Muffle, and is made in the following manner.

On an oblong ſquare, of four inches in breadth, and ſix or ſeven in length, a concave ſemi-cylinder is erected, in the form of a vault, which makes a ſemi-circular canal, open at both ends. One of theſe is almoſt entirely cloſed, except that near the bottom two ſmall ſemi-circular holes are left. In each of its ſides likewiſe two ſuch holes are made, and the other end is left quite open.

The Muffle is intended to bear and communicate the fierceſt heat; and therefore it muſt be made thin, and of an earth that will reſiſt the violence of fire, ſuch as that of which crucibles are made. The Muffle being thus conſtructed, and then well baked, is fit for uſe.

When it is to be uſed it muſt be put into the furnace by the upper opening, and ſet upon two iron bars, introduced through the holes made for that purpoſe below the door of the fire-place. The Muffle muſt be placed on theſe bars in the fire-place in ſuch a manner that its open end ſhall ſtand next to, and directly againſt the door of the fire-place, and may be joined to it with lute. Then the cupels are ranged in it, and the furnace is filled up, to the heighth of two or three inches above the Muffle, with ſmall coals not bigger than a walnut, to the end that they may lie cloſe round the Muffle, and procure it an equal heat on every ſide. The chief uſe of the Muffle is to prevent the coals and aſhes from falling into the cupels, which would be very prejudicial to the operations carrying on in them: for the lead would not vitrify as it ought, becauſe the immediate contact of the coals would continually reſtore its phlogiſton; or elſe the glaſs of lead, which ought to penetrate and paſs through the cupels, would be rendered incapable of ſo doing; becauſe the aſhes mixing therewith would give it ſuch a conſiſtence and tenacity as would deſtroy that property, or at leaſt conſiderably leſſen it. The openings, therefore, which are left in the lower part of the Muffle, ſhould not be ſo high as to admit coals or aſhes to get into the cupels; the uſe of them is to procure an eaſier paſſage for the heat and the air to thoſe veſſels. The Muffle is left quite open in its fore-part, that the operator may be at liberty to examine what paſſes in the cupels, to ſtir their contents, to remove them from one place to another, to convey new matters into them, *&c.* and alſo to promote the free acceſs of the air, which muſt concur with the fire towards the evaporation neceſſary to the vitrification of lead; which air, if freſh were not often enough admitted, would be incapable of producing that effect; becauſe it would ſoon be loaded with ſuch a quantity of vapours that it could not take up any more.

The government of the fire in this furnace is founded on the general principles above laid down for all furnaces. Yet as there are ſome little differences, and as it is very eſſential to the ſucceſs of the operations for which this furnace is intended, that the artiſt ſhould be abſolutely maſter of his degree of heat, we ſhall in few words ſhew how that may be raiſed or lowered.

When the furnace is filled with coals and kindled, if the door of the aſh-hole be ſet wide open, and that of the fire-place ſhut very cloſe, the force of the fire is increaſed; and if, moreover, the pyramidal cover be put on the top, and the conical funnel added to it, the fire will become ſtill more fierce.

Seeing the matters contained in this furnace are encompaſſed with fire on all ſides, except in the fore-part oppoſite to the door of the fire-place, and as there are occaſions which require that the force of the fire ſhould be applied to this part alſo, an iron box, of the ſhape and ſize of the door, hath been contrived to anſwer that purpoſe. This box is filled with lighted coals, and applied immediately to the door-place, by which means the heat there is conſiderably augmented. This help may be made uſe of at the beginning of the operation, in order to accelerate it, and bring the heat ſooner to the deſired degree; or in caſe a very fierce heat be required; or at a time when the air being hot and moiſt will not make the fire burn with the neceſſary vigour.

The heat may be leſſened by removing the iron box, and ſhutting the door of the fire-place quite cloſe. It may be ſtill further and gradually diminiſhed, by taking off the conical funnel from the top; by ſhutting the door of the fire-place with one of its plates only, that which has the leaſt, or that which has the greateſt aperture in it; by taking off the pyramidal cover; by ſhutting the aſh-hole door wholly or in part; and, laſtly, by ſetting the door of the fire-place wide open: but, in this laſt caſe, the cold air penetrates into the cavity of the Muffle, and refrigerates the cupels more than is almoſt ever neceſſary. If it be obſerved, during the operation, that the Muffle grows cold in any particular part, it is a ſign there is a vacuity left by the coals in that place: in this caſe an iron wire muſt be thruſt into the furnace, through the hole which is over the door of the fire-place, and the coals ſtirred therewith, ſo as to make them fall into their places and fill up the vacant interſtices.

It is proper to obſerve, that, beſides what has been ſaid concerning the ways of increaſing the activity of the fire in the cupelling furnace, ſeveral other cauſes alſo may concur to procure to the matters contained in the Muffle a greater degree of heat: for example, the ſmaller the Muffle is, the wider and more numerous the holes in it are; the nearer to its bottom, or further end, the cupels are placed, the more will the matters therein contained be affected with heat.

Beſides the operations to be performed by the cupel, this furnace is very uſeful, and even neceſſary, for many chymical experiments; ſuch, for inſtance, as thoſe relating to ſundry vitrifications and enamelling. As it is pretty low, the beſt way is to place it, when it is to be uſed, on a baſe of brick-work that may raiſe it to a level with the operator's hand.

A Lamp-furnace is exceeding uſeful for all operations that require only a moderate, but long-continued, degree of heat. The furnace for working with a lamp-heat is very ſimple: it conſiſts only of a hollow cylinder, from fifteen to eighteen inches high, and five or ſix in diameter, having at its bottom an aperture large enough for a lamp to be introduced and withdrawn with eaſe. The lamp muſt have three or four wicks, to the end that by lighting more or fewer of them a greater or leſs degree of heat may be produced. The body of the furnace muſt moreover have ſeveral ſmall holes in it, in order to ſupply the flame of the lamp with air enough to keep it alive.

On the top of this furnace ſtands a baſon five or ſix inches deep, which ought to fill the cavity of the cylinder exactly, and to be ſupported at its circumference by a rim which may entirely cover and cloſe the furnace: the uſe of this baſon is to contain the ſand through which the lamp-heat is uſually conveyed.

Beſides this, there muſt be a kind of cover or dome made of the ſame material with the furnace, and of the ſame diameter with the ſand-bath, without any other opening than a hole, nearly circular, cut in its lower extremity. This dome is a ſort of reverberatory, which ſerves to confine the heat and direct it towards the body of the retort; for it is uſed only when ſomething is to be diſtilled in a veſſel of this faſhion; and then the hole at its bottom ſerves for a paſſage to the neck of the retort. This dome ſhould have an ear or handle, for the conveniency of putting it on and taking it off with eaſe.

Of Lutes.

CHYMICAL veſſels, eſpecially ſuch as are made of glaſs, and the earthen veſſels commonly called ſtone-ware, are very ſubject to break when expoſed to ſudden heat or cold: whence it comes, that they often crack when they begin to heat, and alſo when being very hot they happen to be cooled, either by freſh coals thrown into the furnace, or by the acceſs of cold air. There is no way to prevent the former of theſe accidents, but by taking the pains to warm your veſſel very ſlowly, and by almoſt inſenſible degrees. The ſecond may be avoided by coating the body of the veſſel with a paſte or lute, which being dried will defend it againſt the attacks of cold.

The fitteſt ſtuff for coating veſſels is a compoſition of fat earth, Windſor-loam, fine ſand, filings of iron, or powdered glaſs, and chopped cow's hair, mixed and made into a paſte with water. This lute ſerves alſo to defend glaſs veſſels againſt the violence of the fire, and to prevent their melting eaſily.

In almoſt all diſtillations it is of great conſequence, as hath been ſaid, that the neck of the diſtilling veſſel be exactly joined with that of the receiver into which it is introduced, in order to prevent the vapours from eſcaping into the air and ſo being loſt: and this junction is effected by means of a lute.

A few ſlips of paper applied round the neck of the veſſels with common ſize will be ſufficient to keep in ſuch vapours as are aqueous, or not very ſpirituous.

If the vapours are more acrid, or more ſpirituous, recourſe may be had to ſlips of bladder long ſteeped in water, which containing a ſort of natural glue, cloſe the junctures of the veſſels very well.

If it be required to confine vapours of a ſtill more penetrating nature, it will be proper to employ a lute that quickly grows very hard; particularly a paſte made with quick-lime and any ſort of jelly, whether vegetable or animal; ſuch as the white of an egg, ſtiff ſize, *&c.* This is an excellent lute, and not eaſily penetrated. It is alſo uſed to ſtop any cracks or fractures that happen to glaſs veſſels. But it is not capable of reſiſting the vapours of mineral acid ſpirits, eſpecially when they are ſtrong and ſmoking: for that purpoſe it is neceſſary to incorporate the other ingredients thoroughly with fat earth ſoftened with water; and even then it frequently happens that this lute is penetrated by acid vapours, eſpecially thoſe of the ſpirit of ſalt, which of all others are confined with the greateſt difficulty.

In ſuch caſes its place may be ſupplied with another, which is called Fat Lute, becauſe it is actually worked up with fat liquors. This lute is compoſed of a very fine cretaceous earth, called tobacco-pipe clay, moiſtened with equal parts of the drying oil of lint-ſeed, and a varniſh made of amber and gum copal. It muſt have the conſiſtence of a ſtiff paſte. When the joints of the veſſels are cloſed up with this lute, they may, for greater ſecurity, be covered over with ſlips of linen ſmeared with the lute made of quick-lime and the white of an egg.

Chymical veſſels are liable to be broken in an operation by other cauſes beſides the ſudden application of heat or cold. It frequently happens, that the vapours of the matters expoſed to the action of fire ruſh out with ſuch impetuoſity, and are ſo elaſtic, that, finding no paſſage through the lute with which the joints of the veſſels are cloſed, they burſt the veſſels themſelves, ſometimes with exploſion and danger to the operator.

To prevent this inconvenience, it is neceſſary that in every receiver there be a ſmall hole, which being ſtopped only with a little lute may eaſily be opened and ſhut again as occaſion requires. It ſerves for a vent-hole to let out the vapours, when the receiver begins to be too much crowded with them. Nothing but practice can teach the artiſt when it is requiſite to open this vent. If he hits the proper time, the vapours commonly ruſh out with rapidity, and a conſiderable hiſſing noiſe; and the vent ſhould be ſtopped again as ſoon as the hiſſing begins to grow faint. The lute employed to ſtop this ſmall hole ought always to be kept ſo ductile, that, by taking the figure of the hole exactly, it may entirely ſtop it. Beſides, if it ſhould harden upon the glaſs, it would ſtick ſo faſt that it would be very difficult to remove it without breaking the veſſel. This danger is eaſily avoided by making uſe of the fat lute, which continues pliant for a long time, when it is not expoſed to an exceſſive heat.

This way of ſtopping the vent-hole of the receiver has yet another advantage: for if the hole be of a proper width, as a line and half, or two lines, in diameter, then, when the vapours are accumulated in too great a quantity, and begin to make a great effort againſt the ſides of the receiver, they puſh up the ſtopple, force it out, and make their way through the vent-hole: ſo that, by this means, the breaking of the veſſels may always be certainly prevented. But great care muſt be taken that the vapours be not ſuffered to eſcape in this manner, except when abſolute neceſſity requires it; for it is generally the very ſtrongeſt and moſt ſubtile part of a liquor which is thus diſſipated and loſt.

Heat being the chief cauſe that puts the elaſticity of the vapours in action, and prevents their condenſing into a liquor, it is of great conſequence in diſtillation that the receiver be kept as cool as poſſible. With this view a thick plank ſhould be placed between the receiver and the body of the furnace, to intercept the heat of the latter, and prevent its reaching the former. As the vapours themſelves riſe very hot from the diſtilling veſſel, they ſoon communicate their heat to the receiver, and eſpecially to its upper part, againſt which they ſtrike firſt. For this reaſon it is proper that linen cloths, dipt in very cold water, be laid over the receiver, and frequently ſhifted. By this means the vapours will be conſiderably cooled, their elaſticity weakened, and their condenſation promoted.

By what hath been ſaid in this firſt part, concerning the properties of the principal agents in Chymiſtry, the conſtruction of the moſt neceſſary veſſels and furnaces, and the manner of uſing them, we are ſufficiently prepared for proceeding directly to the operations, without being obliged to make frequent and long ſtops, in order to give the neceſſary explanations on thoſe heads.

Neverthele ſs, we ſhall take every proper occaſion to extend the theory here laid down, and to improve it by the addition of ſeveral particulars, which will find their places in our Treatiſe of Chymical Operations.

ELEMENTS

OF THE

PRACTICE OF CHYMISTRY;

WHEREIN

The Fundamental Operations are deſcribed, and illuſtrated by Obſervations on each Proceſs.

ELEMENTS

OF THE

PRACTICE OF CHYMISTRY.

INTRODUCTION.

AS the Elements of the Theory of Chymiſtry, delivered in the former part of this work, were intended for the uſe of perſons ſuppoſed to be altogether unacquainted with the art, they could not properly admit of any thing more than fundamental principles, ſo diſpoſed as conſtantly to lead from the ſimple to the compound, from things known to things unknown: for which reaſon I could not therein obſerve the uſual order of Chymical Decompoſition, which is not ſuſceptible of ſuch a method. I therefore ſuppoſed all the analyſes made, and bodies reduced to their ſimpleſt principles; to the end that, by obſerving the chief properties of thoſe primary elements, we might be enabled to trace them through their ſeveral combinations, and to form ſome ſort of judgment *a priori* of the qualities of ſuch compounds as may reſult from their junctions.

But this latter part is of a different nature. It is a practical Treatiſe, intended to contain the manner of performing the principal Operations of Chymiſtry; the operations which ſerve as ſtandards for regulating all the reſt, and which confirm the fundamental truths laid down in the Theory.

As theſe operations conſiſt almoſt wholly of analyſes and decompoſitions, there can be no doubt concerning the order proper to be obſerved in giving an account of them: it evidently coincides with that of the analyſis itſelf.

But as all bodies, which are the ſubjects of Chymical operations, are divided by nature into three claſſes or kingdoms, the mineral, the vegetable, and the animal, the analyſis thereof may naturally be divided into three branches: ſome difference may alſo ariſe from the different order in which theſe three may be treated of.

As the reaſons aſſigned for beginning with one kingdom rather than with another have never been thoroughly canvaſſed, and may perhaps ſeem equally good when viewed in a particular light, Chymical writers differ in their opinions on this point. For my part, without entering into a diſcuſſion of the motives which have determined others to follow a different order, I ſhall only produce the reaſons that led me to begin with the mineral kingdom, to examine the vegetable in the ſecond place, and to conclude with the animal.

Firſt, then, ſeeing vegetables draw their nouriſhment from minerals, and animals derive theirs from vegetables, the bodies which conſtitute theſe three kingdoms ſeem to be generated the one by the other, in a manner that determines their natural rank.

Secondly, this diſpoſition procures us the advantage of tracing the principles, from their ſource in the mineral kingdom, down to the laſt combinations into which they are capable of entering, that is, into animal matters; and of obſerving the ſucceſſive alterations they undergo in paſſing out of one kingdom into another.

Thirdly and laſtly, I look upon the analyſis of minerals to be the eaſieſt of all; not only becauſe they conſiſt of fewer principles than vegetables and animals, but alſo becauſe almoſt all of them are capable of enduring the moſt violent action of fire, when that is neceſſary to their decompoſition, without any conſiderable change or diminution of their principles, to which thoſe of other ſubſtances are frequently liable.

Beſides, I am not ſingular in this diſtribution of the three claſſes of bodies, which are the ſubjects of the chymical analyſis: as it is the moſt natural, it has been adopted by ſeveral authors, or rather by moſt who have publiſhed Treatiſes of Chymiſtry. But there is ſomething peculiarly my own in the manner wherein I have treated the analyſis of each kingdom. In the mineral kingdom, for inſtance, will be found a conſiderable number of operations not to be met with in other Treatiſes of Chymiſtry; the authors having probably conſidered them as uſeleſs, or in ſome meaſure foreign, to the purpoſe of Elementary Books, and as conſtituting together a diſtinct art. I mean the proceſſes for extracting ſaline and metallic ſubſtances from the minerals containing them.

Yet, if it be conſidered that ſalts, metals, and ſemi-metals are far from being produced by nature in a ſtate of perfection, or in that degree of purity which they are commonly ſuppoſed to have when they are firſt treated of in Books of Chymiſtry; but that, on the contrary, theſe ſubſtances are originally blended with each other, and adulterated with mixtures of heterogeneous matters, wherewith they form compound minerals; I imagine it will be allowed, that the operations by which theſe minerals are decompoſed, in order to extract the metals, ſemi-metals, and other ſimpler ſubſtances, eſpecially as they are founded on the moſt curious properties of theſe ſubſtances, are ſo far from being uſeleſs or foreign to the purpoſes of an Elementary Treatiſe, that they are, on the contrary, abſolutely neceſſary thereto.

After I had made theſe reflections, I could not help thinking that an analyſis of minerals, which ſhould treat of ſaline and metallic ſubſtances, without taking any notice of the manner in which their matrices muſt be analyſed, in order to extract them, would be no leſs defective than a treatiſe of the analyſis of vegetables, in which Oils, eſſential Salts, fixed and volatile Alkalis, ſhould be amply treated of, without ſaying one word of the manner of analyſing the plants from which theſe ſeveral ſubſtances are obtained. I therefore thought myſelf indeſpenſably obliged to deſcribe the manner of decompoſing every ore or mineral, before I attempted to treat of the ſaline or metallic ſubſtance which it yields.

For example: as the Vitriolic Acid, with the conſideration of which I begin my Mineral Analyſis, is originally contained in Vitriol, Sulphur, and Alum; and as theſe ſubſtances again derive their origin from the ſulphureous and ferruginous Pyrites, the firſt operations I deſcribe under this head are the proceſſes for decompoſing the Pyrites in order to extract its Vitriol, Sulphur, and Alum. I then proceed to the particular analyſis of each of theſe ſubſtances, with a view to extract their Vitriolic Acid; and afterwards deliver, in their order, the other operations uſually performed on this Acid. Thus it appears, that this ſaline ſubſtance occaſions my deſcribing the analyſes of the Pyrites, Vitriol, Sulphur, and Alum. The whole of the Treatiſe on Minerals proceeds on the ſame plan.

The operations by which we decompoſe ores and minerals are of two ſorts: thoſe employed in working by the great, and thoſe for trying in ſmall the yield of any ore. Theſe two manners of operating are ſometimes a little different; yet in the main they are the ſame, becauſe they are founded on the ſame principles, and produce the ſame effects.

As my chief deſign was to deſcribe the operations that may be conveniently performed in a laboratory, I have preferred the proceſſes for ſmall aſſays: eſpecially as they are uſually performed with more care and accuracy than the operations in great works: and here I muſt acknowledge, that I am obliged to M. Cramer's *Docimaſia*, or Art of Aſſaying, for all the operations of this kind in my analyſis of minerals. As M. Hellot's work on that ſubject did not appear till after I had finiſhed this, M. Cramer's *Docimaſia*, in which ſound Theory is joined with accurate practice, was the beſt book of the kind I could at that time conſult. I therefore preferred it to all others; and as I have not quoted it in my analyſis of minerals, becauſe the quotations would have been too frequent, let what I ſay here ſerve for a general quotation. I have been careful to name, as often as occaſion required, the other authors whoſe proceſſes I have borrowed: it is a tribute juſtly due to thoſe who have communicated their diſcoveries to the public.

Though I have told the reader that in my analyſis of minerals he will find the proceſſes for extracting out of each the ſaline or metallic ſubſtances contained in it, yet he muſt not expect that this book will inſtruct him in all that is neceſſary he ſhould know to be able to determine, by an accurate aſſay, the contents of every mineral. My intention was not to compoſe a Treatiſe of Aſſaying; and I have taken in no more than was abſolutely neceſſary to make the analyſis of minerals perfectly underſtood, and to render it as complete as it ought to be in an Elementary Treatiſe. I have therefore deſcribed only the principal operations relating thereto; the operations which are fundamental, and which, as I ſaid before, are to ſerve as ſtandards for the reſt, abſtracted from ſuch additional circumſtances as are of conſequence only to the Art of Aſſaying, properly ſo called.

Such therefore as are deſirous of being fully inſtructed in that Art, muſt have recourſe to thoſe works which treat profeſſedly of the ſubject; and particularly to that publiſhed by M. Hellot: a performance moſt eſteemed by ſuch as are beſt ſkilled in Chymiſtry, and rendered ſo complete by the numerous and valuable obſervations and diſcoveries of the Author, that nothing better of the kind can be wiſhed for. I thought it proper to give theſe notices in relation to my analyſis of minerals; and ſhall now proceed to ſhew the plan of my analyſes of vegetables and of animals.

Seeing all vegetable matters are ſuſceptible of fermentation, and when analyſed after fermentation, yield principles different from thoſe we obtain from them before they are fermented, I have divided them into two claſſes; the former including vegetables in their natural ſtate, before they have undergone fermentation; and the latter thoſe only which have been fermented. This analyſis opens with the proceſſes by which we extract from vegetables all the principles they will yield without the help of fire: and then follow the operations for decompoſing plants by degrees of heat, from the gentleſt to the moſt violent, both in cloſe veſſels, and in the open air.

I have not made the ſame diviſion in the animal kingdom, becauſe the ſubſtances that compoſe it are ſuſceptible only of the laſt degree of fermentation, or putrefaction; and moreover the principles they yield, whether putrefied or unputrefied, are the very ſame, and differ only with regard to their proportions, and the order in which they are extricated during the analyſis.

I begin this analyſis with an examination of the milk of animals that feed wholly on vegetables; becauſe, though this ſubſtance be elaborated in the body of the animal, and by that means brought nearer to the nature of animal matters, yet it ſtill retains a great ſimilitude to the vegetables from which it derives its origin, and is a ſort of intermediate ſubſtance between the vegetable and animal. Then I proceed to the analyſis of animal matters properly ſo called, thoſe which actually make a part of the animal body. I next examine the excrementitious ſubſtances, that are thrown out of the animal body as ſuperfluous and uſeleſs. And then I conclude this latter part with operations on the Volatile Alkali; a ſaline ſubſtance of principal conſideration in the decompoſition of animal matters.

Though, in the general view here given of the order obſerved in this Treatiſe of Practical Chymiſtry, I have mentioned only ſuch proceſſes as ſerve for analyſing bodies, yet I have alſo inſerted ſome other operations of different kinds.

The book would be very defective if it contained no more: for the deſign of Chymiſtry is not only to analyſe the mixts produced by nature, in order to obtain the ſimpleſt ſubſtances of which they are compoſed, but moreover to diſcover by ſundry experiments the properties of thoſe elementary principles, and to recombine them in various manners, either with each other, or with different bodies, ſo as to reproduce the original mixts with all their properties, or even form new compounds which never exiſted in nature. In this book therefore the reader will find proceſſes for combining and recompounding, as well as for reſolving and decompoſing bodies. I have placed them next to the proceſſes for decompoſition, taking all poſſible care not to interrupt their order, or break the connection between them.

PART I.

OF MINERALS.

SECTION I.

Operations performed on Saline Mineral Subſtances.

CHAP. I.

Of the VITRIOLIC ACID.

PROCESS I.

To extract Vitriol from the Pyrites.

TAKE any quantity you pleaſe of Iron Pyrites; leave them for ſome time expoſed to the air: they will crack, ſplit, loſe their brightneſs, and fall into powder. Put this powder into a glaſs cucurbit, and pour upon it twice its weight of hot water; ſtir the whole with a ſtick, and the liquor will grow turbid. Pour it, while it is yet warm, into a glaſs funnel lined with brown filtering paper; and having placed your funnel over another glaſs cucurbit, let the liquor drain into it. Pour more hot water on the powdered Pyrites, filter as before, and ſo go on, every time leſſening the quantity of water, till that which comes off the Pyrites appears to have no aſtringent vitriolic taſte.

Put all theſe waters together into a glaſs veſſel that widens upwards; ſet it on a ſand bath, and heat the liquor till a conſiderable ſmoke ariſes; but take care not to make it boil. Continue the ſame degree of fire till the ſurface of the liquor begins to look dim, as if ſome duſt had fallen into it; then ceaſe evaporating, and remove the veſſel into a cool place: in the ſpace of four and twenty hours will be formed therein a quantity of cryſtals, of a green colour and a rhomboidal figure: theſe are Vitriol of Mars, or Copperas. Decant the remaining liquor; add thereto twice its weight of water; filter, evaporate, and cryſtallize as before; repeat theſe operations till the liquor will yield no more cryſtals, and keep by themſelves the cryſtals obtained at each cryſtallization.

OBSERVATIONS.

THE Pyrites are minerals which, by their weight and ſhining colours, frequently impoſe on ſuch as are not well acquainted with ores. At firſt ſight they may be taken for very rich ones; and yet they conſiſt only of a ſmall quantity of metal combined with much ſulphur or arſenic, and ſometimes with both.

They ſtrike fire with a ſteel as flints do, and emit a ſulphureous ſmell: ſo that they may be known by this extemporaneous proof. The metal moſt commonly and moſt abundantly found in the Pyrites is iron; the quantity whereof ſometimes equals, or even exceeds, that of the ſulphur. Beſides metallic and ſulphureous matters, the Pyrites contain alſo ſome unmetallic earth.

There are ſeveral ſorts of Pyrites: ſome of them contain only iron and arſenic. They have not all the property of efflorefcing ſpontaneouſly in the air, and turning into vitriol: none do ſo but ſuch as conſiſt only of iron and ſulphur, or at leaſt contain but a very ſmall portion of copper, or of arſenic: and even amongſt thoſe that are compoſed of iron and ſulphur alone, there are ſome that will continue for years together expoſed to the air without ſhooting, and indeed without ſuffering the leaſt ſenſible alteration.

The efflorefcence of the Iron Pyrites, and the changes they undergo, are phenomena well worth our notice. They depend on the ſingluar property which iron poſſeſſes of decompoſing ſulphur by the help of moiſture. If very fine iron-filings be accurately mingled with flowers of ſulphur, this mixture, being moiſtened with water, grows very hot, ſwells up, emits ſulphureous vapours, and even takes fire; what remains is found converted into Vitriol of Mars. On this occaſion, therefore, the ſulphur is decompoſed; its inflammable part is diſſipated or conſumed; its acid combines with the iron, and a Vitriol ariſes from that conjunction.

This is the very caſe with the Pyrites that conſiſt only of iron and ſulphur; yet ſome of them, as we ſaid before, do not effloreſce ſpontaneouſly and turn to Vitriol. The reaſon probably is, that, in ſuch minerals, the particles of iron and ſulphur are not intimately mixed together, but ſeparated by ſome earthy particles.

In order to procure Vitriol from Pyrites of this kind, they muſt be for ſome time expoſed to the action of fire, which, by conſuming part of their ſulphur, and rendering their texture leſs compact, makes way for the air and moiſture, to which they muſt be afterwards expoſed, to penetrate their ſubſtance, and produce in them the changes with which thoſe others are affected that germinate ſpontaneouſly.

The Pyrites which contain copper and arſenic, and for that reaſon do not effloreſce, muſt likewiſe undergo the action of fire; which, beſides the effects it produces on Pyrites that conſiſt of iron and ſulphur only, diſſipates alſo the greateſt part of the arſenic. Theſe Pyrites being firſt roaſted, and then expoſed to the air for a year or two, do alſo yield Vitriol; but then it is not a pure Vitriol of Iron, but is combined with a portion of blue Vitriol, the baſis of which is Copper.

Sometimes alſo there is Alum in the vitriolic waters drawn off the Pyrites. It was on account of this mixture of different ſalts that we recommended the keeping apart the cryſtals obtained from each different cryſtallization: for by this means they may be examined ſeparately, and the ſpecies to which they belong diſcovered.

When Vitriol of Iron is adulterated with a mixture of the Vitriol of Copper only, it is eaſy to purify it and bring it to be entirely martial, by diſſolving it in water, and ſetting plates of iron in the ſolution: for Iron having a greater affinity than copper with the vitriolic acid, ſeparates the latter from it, and aſſuming its place produces a pure Vitriol of Mars.

In large works for extracting Vitriol from the Pyrites they proceed thus. They collect a great quantity of Pyrites on a piece of ground expoſed to the air, and pile them up in heaps of about three feet high. There they leave them expoſed to the action of the air, ſun, and rain, for three years together; taking care to turn them every ſix months, in order to facilitate the effloreſcence of thoſe which at firſt lay undermoſt. The rain-water which has waſhed thoſe Pyrites is conveyed by proper channels into a ciſtern; and when a ſufficient quantity thereof is gathered, they evaporate it to a pellicle in large leaden boilers, having firſt put into it a quantity of iron, ſome part of which is diſſolved by the liquor, becauſe it contains a vitriolic acid that is not fully ſaturated therewith. When it is ſufficiently evaporated, they draw it off into large leaden or wooden coolers, and there leave it to ſhoot into cryſtals. In theſe laſt veſſels ſeveral ſticks are placed, croſſing each other in all manner of directions, in order to multiply the ſurfaces on which the cryſtals may faſten.

The Pyrites are not the only minerals from which Vitriol may be procured. All the ores of iron and copper that contain ſulphur may alſo be made to yield green or blue Vitriol, according to the nature of each, by torrefying them, and leaving them long expoſed to the air: but this uſe is ſeldom made of them, as there is more profit to be got by extracting the metals they contain. Beſides, it is eaſier to obtain Vitriol from the Pyrites than from thoſe other mineral ſubſtances.

PROCESS II.

To extract Sulphur from the Pyrites, and other ſulphureous Minerals.

REDUCE to a coarſe powder any quantity of yellow Pyrites, or other Mineral containing Sulphur. Put this powder into an earthen or glaſs retort, having a long wide neck, and ſo large a body that the matter may fill but two thirds of it. Set the retort in a ſand-bath fixed over a reverberating furnace: fit to it a receiver half full of water, and ſo placed that the noſe of the retort may be about an inch under the water: give a gradual fire, taking care you do not make it ſo ſtrong as to melt the matter. Keep the retort moderately red for one hour, or an hour and half, and then let the veſſels cool.

Almoſt all the Sulphur ſeparated by this operation from its matrix will be found at the extremity of the neck of the retort, being fixed there by the water. You may get it out either by melting it with ſuch a gentle heat as will not ſet it on fire, or by breaking the neck of the retort.

OBSERVATIONS.

OF all minerals the Pyrites contain the moſt Sulphur; thoſe eſpecially which have the colour of fine braſs, a regular form, ſuch as round, cubical, hexagonal, and being broken preſent a number of ſhining needles, all radiating, as it were, from a center.

A very moderate heat is ſufficient to ſeparate the Sulphur they contain. We directed that the retort employed ſhould have a long and wide neck, with a view to procure a free paſſage for the Sulphur: the water ſet in the receiver detains the Sulphur, fixes it, and prevents it from flying off; ſo that it is unneceſſary to cloſe the joints of the veſſels. But it is proper to take notice, that whenever you uſe an apparatus for diſtilling, which requires the beak of the retort to be under water, it is of very great conſequence that the fire be conſtantly ſo regulated, that the retort may not cool in the leaſt; for, in that caſe, as the rarefied air contained therein would be condenſed, the water in the receiver would riſe into the retort and break it.

If in diſtilling Sulphur, according to the preſent proceſs, the matter contained in the retort ſhould happen to melt, the operation would be thereby conſiderably protracted, and it would require a great deal more time to extract all the Sulphur; becauſe all evaporation is from the ſurface only, and the matter, while it remains in a coarſe powder, preſents a much more extenſive ſurface than when it is melted.

This remark holds with regard to all other diſtillations. Any quantity of liquor, ſet to diſtil in its fluid ſtate, will take much more time to riſe in vapours, and paſs from the retort into the receiver, than if it be incorporated with ſome ſolid body reduced to minute parts, ſo that the whole ſhall make a moiſt powder; and this though the very ſame degree of fire be applied in both caſes.

If the matter from which it is propoſed to extract Sulphur be ſuch as will melt with the degree of fire neceſſary to this operation; that is, with a heat which will make the retort but faintly red, it muſt be mixed with ſome ſubſtance that is not ſo fuſible. Very pure coarſe ſand, or clean gravel, may be uſed with ſucceſs: but abſorbent earths are altogether improper for this purpoſe, becauſe they will unite with the Sulphur.

The ſulphureous minerals which are moſt apt to fuſe are the cupreous Pyrites, or yellow copper ores: common lead ores are alſo very fuſible.

The Pyrites are by this operation deprived of almoſt all the Sulphur they contain; and conſequently little is left behind, but the particles of iron and copper, together with a portion of unmetallic earth, which we ſhall ſhew how to ſeparate from theſe metals, when we come to treat of them. I ſay that by this operation the Pyrites are deprived of almoſt all, and not entirely of all their Sulphur; becauſe, this ſeparation being made in cloſe veſſels only, there always remains a certain quantity of Sulphur, which adheres ſo obſtinately to the metals, that it would be almoſt impoſſible to get it all out, even though a much ſtronger fire than that directed in the proceſs were applied for this purpoſe, and though choice had been, as it ought to be, made of ſuch Pyrites, or other ſulphureous Minerals as part moſt eaſily with their ſulphur. Nothing but a very ſtrong fire in the open air is capable of carrying it wholly off, or conſuming it entirely.

In ſeveral places are found great quantities of native Sulphur. The Volcanoes abound with it, and people gather it at the foot of thoſe burning mountains. Several ſprings of mineral waters alſo yield Sulphur, and it is ſometimes found ſublimed to the vaulted roofs of certain wells, and among others in one at Aix-la-Chapelle.

The Germans and Italians have large works for extracting Sulphur in quantities out of Pyrites, and other minerals which abound therewith. The proceſs they work by is the ſame with that here delivered; but with this difference only, that Sulphur being but of ſmall value they do not uſe ſo many precautions. They content themſelves with putting the ſulphureous minerals into large crucibles, or rather earthen cucurbits, which they place in the furnace in ſuch a manner that, when the ſulphureous part melts, it runs into veſſels filled with water, and is thereby fixed.

The Sulphur obtained, either by diſtillation or by ſimple fuſion, is not always pure.

When it is obtained by diſtillation, if the matters from which you extract it contain moreover ſome other minerals of nearly the ſame volatility, ſuch, for inſtance, as Arſenic, or Mercury, theſe minerals will come over with it. This is eaſily perceived: for pure ſublimed Sulphur is always of a beautiful yellow, inclining to a lemon colour. If it look red, or have a reddiſh caſt, it is a ſign that ſome Arſenic hath riſen along with it.

Mercury ſublimed with Sulphur likewiſe gives it a red colour; but Sulphur is very ſeldom adulterated with this metallic ſubſtance: for Arſenic is frequently found combined with the Pyrites, and other ſulphureous minerals; whereas, on the contrary, we very rarely meet with any Mercury in them.

But if Mercury ſhould happen to riſe with the Sulphur in diſtillation, it may be diſcovered by examining the ſublimate; which, in that caſe, will have the properties of Cinabar: on being broken its inſide will appear to conſiſt of needles adhering laterally to each other; its weight will be very conſiderable; and, laſtly, the great heat of the place where it is collected will furniſh another mark to know it by; for, as Cinabar is leſs volatile than Arſenic or Sulphur, it faſtens on places too hot for either Sulphur or Arſenic to bear.

Sulphur may alſo be adulterated with ſuch fixed matters, either metallic or earthy, as it may have carried up along with it in the diſtillation, or as may have been ſublimed by the Arſenic, which has a ſtill greater power than Sulphur to volatilize fixed bodies.

If you deſire to free the Sulphur from moſt of theſe heterogeneous matters, it muſt be put into an earthen cucurbit, and ſet in a ſand-bath. To the cucurbit muſt be fitted one or more aludels, and ſuch a degree of heat applied as ſhall but juſt melt the Sulphur; which is much leſs than that neceſſary to ſeparate the Sulphur from its matrix. As ſoon as the Sulphur is melted it will ſublime in lemon-coloured flowers, that will ſtick to the inſides of the aludels.

When nothing more appears to riſe with this degree of heat, the veſſels muſt be ſuffered to cool. At the bottom of the cucurbit will be found a ſulphureous maſs, containing the greateſt part of the adventitious matters that were mixed with the Sulphur, and more or leſs red or dark-coloured, according to the nature of thoſe matters.

When we come to treat of Arſenic and Mercury, we ſhall give the methods of ſeparating Sulphur entirely from thoſe metallic ſubſtances.

PROCESS III.

To extract Alum from aluminous Minerals.

TAKE ſuch minerals as are known or ſuſpected to contain Alum. Expoſe them to the air, that they may effloreſce. If they remain there a year without any ſenſible change, calcine them, and then leave them expoſed to the air, till a bit thereof being put on the tongue imparts an aſtringent aluminous taſte.

When your matters are thus prepared, put them into a leaden or glaſs veſſel; pour upon them thrice their weight of hot water; boil the liquor; filter it; and repeat theſe operations till the earth be ſo edulcorated that the water which comes off it hath no taſte. Mix all theſe ſolutions together, and let them ſtand four and twenty hours, that the groſs and earthy parts may ſettle to the bottom; or elſe filter the liquor: then evaporate till it will bear a new-laid egg. Now let it cool, and ſtand quiet four and twenty hours: in that time ſome cryſtals will ſhoot, which are moſt commonly vitriolic; for Alum is rarely obtained by the firſt cryſtallization. Remove theſe vitriolic cryſtals: if any cryſtals of Alum be found amongſt them, theſe muſt be diſſolved anew, and ſet to cryſtallize a ſecond time in order to their purification; becauſe they partake of the nature as well as of the colour of vitriol. By this method extract all the Alum that the liquor will yield.

If you get no cryſtals of Alum by this means, boil your liquor again, and add to it a twentieth part of its weight of a ſtrong alkaline lixivium, or a third part of its weight of putrefied urine, or a ſmall quantity of quick-lime. Experience and repeated trials muſt teach you which of theſe three ſubſtances is to be preferred, according to the particular nature of the mineral on which you are to operate. Keep your liquor boiling, and if there be any alum in it, there will appear a white precipitate: in that caſe let it cool and ſettle. When the white precipitate is entirely fallen, decant the clear, and leave the cryſtals of Alum to ſhoot at leiſure, till the liquor will yield no more: it will then be exceeding thick.

OBSERVATIONS.

ALUM is obtained from ſeveral ſorts of Minerals. In ſome parts of Italy, and in ſundry other places, it effloreſces naturally on the ſurface of the earth. There it is ſwept together with brooms, and thrown into pits full of water. This water is impregnated therewith till it can diſſolve no more. Then it is filtered, and ſet to evaporate in large leaden veſſels; and when it is ſufficiently evaporated, and ready to ſhoot into cryſtals, it is drawn off into wooden coolers, and there left for the ſalt to cryſtallize.

In aluminous ſoils there are often found ſprings ſtrongly impregnated with Alum: ſo that to obtain it, the water need only be evaporated.

In the country about Rome there is a very hard ſtone, which is hewn out of the quarry juſt like other ſtones for building; this ſtone yields a great deal of Alum. In order to extract it, the ſtones are calcined for twelve or fourteen hours; after which they are expoſed to the air in heaps, and carefully watered three or four times a-day for forty days together. In that time they begin to effloreſce, and to throw out a reddiſh matter on their ſurface. Then they are boiled in water, which diſſolves all the Alum they contain, and, being duly evaporated, gives it back in cryſtals. This is the Alum called *Roman Alum.*

Several ſorts of Pyrites alſo yield a great deal of Alum. The Engliſh have a ſtone of this kind, which, in colour, is very like a ſlate. This ſtone contains much Sulphur, which they get rid of by roaſting it. After this they ſteep the calcined ſtone in water, which diſſolves the Alum it contains, and to this ſolution they add a certain quantity of a lye made of the aſhes of ſea-weeds.

The Swedes have a Pyrites of a bright golden colour, variegated with ſilver ſpots, from which they procure Sulphur, Vitriol, and Alum. They ſeparate from it the Sulphur and the Vitriol by the methods above preſcribed. When the liquor which hath yielded Vitriol is become thick, and no more vitriolic cryſtals ſhoot in it, they add an eighth part of its weight of putrefied urine, mixed with a lye made of the aſhes of green wood. Upon this there appears and falls to the bottom a copious red ſediment. They decant the liquor from this precipitate, and, when it is duly evaporated, find it ſhoot into beautiful cryſtals of Alum.

What hath been ſaid, concerning the ſeveral matrices from which Alum is obtained, ſufficiently ſhews, that it is ſeldom ſolitary in the waters with which aluminous ſubjects have been lixiviated. It is almoſt always accompanied with a certain quantity of Vitriol, or other ſaline mineral matters, which obſtruct its cryſtallization, and prevent its being pure. It is with a view to free it from theſe matters, that the waters impregnated with Alum are mixed with a certain quantity of the lye of ſome fixed Alkali, or with putrefied urine, which contains much volatile Alkali. Theſe Alkalis have the property of decompounding all the Neutral ſalts which have for their baſis either an abſorbent earth or a metallic ſubſtance; and ſuch as have a metallic ſubſtance for their baſis more readily than thoſe whoſe baſis is an earth. Conſequently, if they are mixed with a liquor in which both theſe ſorts of ſalts are diſſolved, they muſt decompound that ſort whoſe baſis is metallic ſooner than the other whoſe baſis is an earth. This is what comes to paſs in a ſolution of

Alum and Vitriol. The metallic part of the latter is ſeparated from its acid by the Alkalis when mixed with that ſolution; and it is this metallic part, which is generally iron, that appears in the form of a reddiſh precipitate, as abovementioned.

But becauſe Alkalis decompound alſo thoſe Neutral ſalts which have an earth for their baſis, care muſt be taken that too much thereof be not added; elſe what you put in, more than is neceſſary to decompound the vitriolic ſalts in your liquor, will attack the Alum, and decompound it likewiſe.

The Alkali made uſe of to promote the cryſtallization of the Alum joins with the Vitriolic Acid, which had diſſolved the ſubſtances now precipitated, and therewith forms different Neutral ſalts according to its particular nature. If the Alkali be a lixivium of common wood-aſhes, the Neutral ſalt will be a vitriolated Tartar; if a lixivium of the aſhes of a maritime plant like Soda, the Neutral ſalt will be a Glauber's ſalt; if putrefied urine, the Neutral ſalt will be a vitriolic Ammoniacal ſalt. Some of theſe ſalts incorporate with the Alum, which in large works cryſtallizes in vaſt lumps: and hence it comes that ſome ſorts of Alum when mixed with a fixed Alkali ſmell like a volatile Alkali.

The cryſtals of Alum are octaedral, that is, they are ſolids with eight ſides. Theſe octaedral ſolids are triangular pyramids, having their angles cut away, ſo that four of their ſurfaces are hexagons, and the other four triangles.

Sulphur, Vitriol, and Alum are the three principal ſubjects in which we certainly know that the univerſal or Vitriolic Acid particularly reſides, and from which we extract it when we want to have it pure. For this reaſon we thought it proper, before we treated of the extraction of this Acid, to ſhew the method of ſeparating thoſe matters themſelves from the other minerals out of which we obtain them.

Moreover, all the other matrices, in which the Vitriolic Acid is moſt commonly lodged, may be referred to one or other of the matters which ſerve as baſes to theſe three minerals.

To Sulphur we may refer all combinations of the Vitriolic Acid with an inflammable matter: but we muſt take care not to confound Sulphur with thoſe Bitumens in which the Vitriolic Acid may be found: for the baſis of thoſe bitumens is a real Oil; whereas the baſis of Sulphur is the pure Phlogiſton. Yet as Oils themſelves contain the Phlogiſton, which, in union with the Vitriolic Acid forms a true

Sulphur, it follows that ſuch bitumens may in a certain reſpect be claſſed with Sulphur.

The ſame is to be ſaid of Vitriol. The name is uſually given to ſuch combinations only as are formed of the Vitriolic Acid with Iron or Copper, which make the green and blue Vitriol; and to a third ſpecies of Vitriol, which is white, and has Zinc for its baſis: but as the Vitriolic Acid may, by particular combinations, be united with many other metallic ſubſtances, all ſuch Metallic Salts muſt be referred to the claſs of Vitriols.

The ſame may alſo be ſaid of Alum, which is no other than a combination of the Vitriolic Acid with a particular kind of abſorbent earth; ſo that all combinations of this Acid with any earth whatever may be placed in the ſame claſs.

This laſt claſs of mixts is the moſt extenſive of all that contain the Vitriolic Acid; becauſe there are a vaſt many earths, all differing from one another, with which that Acid may be united. Alum properly ſo called, the Gypſums, Talcs, Selenites, Boles, and all the other compounds of this kind, differ from each other only in their particular earths.

The different properties of theſe earthy ſalts depend on the nature of their baſes. Thoſe which are of the aluminous kind retain much water in cryſtallizing, which makes them very ſoluble in water, and gives them the property of acquiring readily the aqueous fluor when expoſed to the fire. Thoſe which are of the nature of the Selenites admit but very little water in their cryſtals, and conſequently are almoſt inſoluble in water; nor does the fire give them an aqueous fluor. Laſtly, the Gypſums and Talcs are ſtill more deſtitute of theſe properties. The natures of the earths in theſe ſeveral compounds are hitherto but very imperfectly known, and may give the Chymiſts occaſion for inquiries equally curious and uſeful.

The Vitriolic Acid is ſometimes found complicated with a fixed alkaline baſis. This is almoſt always the Alkali of Sea-ſalt; ſo that the compound is a Glauber's Salt. Some mineral waters are impregnated therewith; which happens when theſe waters contain Vitriol or Alum, together with Sea-ſalt.

From the principles laid down, in our Elements of the Theory, it appears that the Vitriolic Acid hath not ſo great an affinity with earthy and metallic ſubſtances as with fixed Alkalis; and alſo that it is ſtronger than the Marine Acid, and hath a greater affinity with fixed Alkalis. This being allowed, the generation of native Glauber's Salts is eaſily accounted for. The Acid of aluminous or vitriolic Salts quits the earth or the metal with which it was combined, and expelling the Acid of Sea-ſalt unites with its baſis. Warmth greatly promotes theſe decompoſitions.

If the common foſſil ſalt, uſually called *Sal Gem*, or any other kind of Sea-ſalt, ſhould happen to be near a Volcano, when it diſcharges flaming Sulphur, as is frequently the caſe, and if this Sulphur ſhould run among the Sea-ſalt, a Glauber's Salt would inſtantly be formed in that place; becauſe when Sulphur burns, its Acid is ſeparated and ſet at liberty.

Laſtly, if aluminous or vitriolic matters, or burning Sulphur, ſhould meet with the aſhes of plants or trees conſumed by fire, a vitriolated Tartar would be formed, becauſe theſe aſhes contain a fixed Alkali of the ſame nature with that of Tartar.

The Vitriolic Acid when combined with an earthy baſis adheres ſtrongly thereto; ſo that the force of fire is able to expel very little or none of it. There is no way of ſeparating it from ſuch a baſis, but by preſenting to it an Alkaline Salt, with which it will unite: nor is it ever extracted from ſuch matters when it is required pure. It does not adhere ſo firmly to metallic ſubſtances; but is ſeparated from them by the force of fire: ſo that it may be obtained from the ſeveral ſorts of Vitriol. It is uſually drawn from Green Vitriol; that being the commoneſt ſort.

As to Sulphur, the Phlogiſton which is its baſis being the ſubſtance wherewith the Vitriolic Acid hath the greateſt affinity, it would be altogether impoſſible to decompoſe it, and to ſeparate its Acid, if it were not inflammable; but by burning it the Phlogiſton is deſtroyed, and leaves the Acid at liberty. By this means therefore it may be ſeparated. We ſhall now give the proceſſes for extracting the Acid from Vitriol and Sulphur.

PROCESS IV.

To extract the Vitriolic Acid from Green Vitriol.

TAKE any quantity of Green Vitriol: put it in an unglazed earthen veſſel, and heat it gradually. Vapours will ſoon begin to riſe. Increaſe the fire a little, and it will liquefy by means of the water contained in it, and acquire what we called an *aqueous* fluor. Continue the calcination, and it will become leſs and leſs fluid, grow thick, and turn of a greyiſh colour. Now raiſe your fire, and keep it up till the ſalt recover its ſolidity, acquire an orange colour, and begin to grow red where it immediately touches the ſides of the veſſel. Then take it out, and reduce it to powder.

Put the Vitriol thus calcined and pulverized into a good earthen retort, of which one half at leaſt muſt remain empty. Set the retort in a reverberatory furnace: fit thereto a large glaſs receiver, and, having luted the joint well, give fire by degrees. You will ſoon ſee white clouds riſe into the receiver, which will render it opaque, and heat it. Continue the ſame degree of fire till theſe clouds diſappear: they will be ſucceeded by a liquor which will trickle down the ſides of the receiver in veins. Still keep up the fire to the ſame degree as long as theſe veins apppear. When they begin to abate, increaſe the fire, and puſh it to the utmoſt extremity: upon this, there will come over a black, thick liquor: it will even be found congealed, and prove the icy Oil of Vitriol, if care hath been taken to change the receiver, keep the veſſels perfectly cloſe, and give a ſufficient degree of heat. Proceed thus till nothing more comes over, or at leaſt very little. Let the veſſels cool, unlute them, pour the contents of the receiver into a bottle, and ſeal it hermetically.

OBSERVATIONS.

GREEN Vitriol retains much water in cryſtallizing; and, in order to free it from that ſuperfluous phlegm, it muſt be calcined before you diſtil it. Without this precaution the operation will be exceedingly protracted, and a great deal of time waſted in diſtilling ſuch a quantity of water; which will moreover greatly weaken the Acid by commixing with it, unleſs care be taken to change the recipient as ſoon as the water is all come over.

But there is alſo another advantage in calcining the Vitriol before you put it into the retort: for otherwiſe this ſalt would melt on the firſt application of heat, and run into a maſs; which would prove a great hindrance to its diſtillation. This inconvenience is avoided by a previous calcination, in conſequence whereof the Vitriol is eaſily reduced to a powder which never becomes fluid.

Vitriol calcined as directed in the proceſs grows ſo hard, and adheres ſo firmly to the veſſel in which the calcination is performed, that it requires no ſmall pains to ſeparate and pulverize it. Care muſt be taken to put it into the retort as ſoon as it is pulverized, and to ſtop that veſſel very cloſe if you do not begin the diſtillation immediately: for otherwiſe it will naturally attract from the air almoſt all the moiſture it hath loſt.

The Acid which Vitriol yields by diſtillation is ſulphureous; probably becauſe it ſtill retains ſome of the Phlogiſton, with which it was united when under the form of ſulphur in the Pyrites; or elſe hath laid hold on a portion of that belonging to the iron which ſerved for its baſis in Vitriol. But this ſulphureous part is volatile, and flies off in time.

This decompoſition of Vitriol in cloſe veſſels is a difficult and laborious proceſs. To carry the operation to its utmoſt perfection requires a fire of extreme violence, kept up without intermiſſion during four or five days; ſuch in ſhort as few veſſels are able to bear. Of courſe this operation is ſeldom performed in laboratories. The French Chymiſts fetch their Oil of Vitriol from Holland, where it is extracted from Vitriol in large quantities, by means of furnaces erected for the purpoſe, in which many retorts are employed at once.

In the Memoirs of the Academy of Sciences M. Hellot hath given us the moſt material circumſtances of a very fine experiment of this kind, in which he puſhed the diſtillation of Green Vitriol to the utmoſt. Into a German retort * he put ſix pounds of Green Engliſh Vitriol calcined to redneſs, which he expoſed to a fire of the extremeſt violence, conſtantly kept up during four days and four nights. At the expiration of that time he found in the veſſels employed as receivers an Icy Oil of Vitriol, which was altogether in a cryſtalline form and black. The precautions neceſſary to make this experiment ſucceed, he repreſents, in the following terms.

" The ſucceſs of this operation, which produces an Oil
" of Vitriol perfectly Icy and without any liquor, depends
" on the care taken to prevent the acid vapours, driven by
" the fire out of Vitriol calcined to redneſs, from having
" any communication with the external air while they are
" diſtilling: for otherwiſe they will attract from it a moi-

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* They are much the beſt, and bear a very fierce heat.

" ſture which will keep them fluid in the receiver. The " receiver muſt be at ſuch a diſtance from the furnace " that it may remain cool enough for the vapours to con- " denſe in it. There muſt alſo be ſufficient room for thoſe " vapours to circulate in, and to prevent the ſulphureous " exploſions, which are every now and then diſcharged out " of the retort, from burſting the veſſels: for though the " previous calcination of the Vitriol hath carried off the " moſt volatile, yet there ſtill remains enough of the inflam- " mable principle, even in the iron itſelf, to form a Sulphur " with the Acid as it is extricated, or at leaſt a mixt that " would be as apt to take fire as common Sulphur, if it were " not over-doſed with the Acid.

" As the beſt means of gaining theſe ends, M. Hellot " contrived to adapt to the neck of his retort a receiver with " two necks, the lowermoſt of which was inſerted into a " large ballon. Receivers applied to each other in this man- " ner are called Adopters.

" It is no eaſy matter to get this Icy Oil out of the ballon: " for as ſoon as the air touches it ſuch a thick cloud of ſul- " phureous fumes ariſes, that it is abſolutely neceſſary to " place the veſſel on ſome ſhelf over head, becauſe a man " cannot ſtand expoſed thereto for a ſingle minute without " being ſuffocated."

This Icy Acid muſt be ſhut up with all poſſible expedition in a cryſtal bottle accurately cloſed with a glaſs ſtopple, which ſhould be ground with emery in its neck ſo as to fit it exactly: for it attracts moiſture ſo powerfully, that, unleſs exceeding great care be taken to prevent all communication with the external air, it will ſoon diſſolve into a fluid.

" The Icy Oil is black; becauſe the acid vapours carry " over with them ſomething of a greaſy matter, from which " Vitriol is ſeldom free, and which always appears, after " repeated ſolutions and cryſtallizations of this Salt, in the " mother-water which will ſhoot no more. Now the ſmall- " eſt portion of inflammable matter preſently blackens the " moſt highly rectified Oil of Vitriol, which is perfectly " clear.

" The Vitriolic Acid, when forced over by a violent heat, " carries along with it ſome ferruginous particles alſo, that " want nothing but to be united with a phlogiſton to become " true iron. They are eaſily diſcovered, either in the com- " mon black Oil of Vitriol, or in the blackiſh cryſtals of " the Icy Oil, by only diſſolving them in a large quantity of

" diſtilled water: for after ſeven or eight days digeſtion a " light powder or downy ſediment precipitates, which being " calcined in a violent fire is partly attracted by the mag- " net; and being again calcined with bees-wax becomes al- " moſt entirely iron."

The *Caput mortuum* of this diſtillation of Vitriol is the ferruginous earth of this Salt, and is called *Colcothar.* When this Colcothar hath undergone a violent fire, as in the experiment now related, ſcarce any Acid remains therein. Out of ſix pounds of Vitriol that M. Hellot uſed, he could recover no more, by lixiviating what was left in the retort, than two ounces of a Vitriolic Salt; and even that was very earthy.

If Vitriol be expoſed to a fire neither ſo violent nor ſo long continued, its Colcothar will yield a greater quantity of Vitriol that hath not been decompoſed. A white cryſtalline ſalt is alſo obtained from it, and called *Salt of Colcothar;* which is no other than the ſmall portion of Alum uſually contained in Vitriol, and not ſo eaſily decompoſed by the the action of fire.

PROCESS V.

To decompoſe Sulphur, and extract its Acid, by burning it.

TAKE any quantity of the pureſt Sulphur: fill therewith a crucible or other earthen diſh: heat it till it melts; then ſet it on fire, and, when its whole ſurface is lighted, place it under a large glaſs head, taking care that the flame of the Sulphur do not touch either its ſides or bottom; that the air have free acceſs, in order to make the Sulphur burn clear; and that the head incline a little toward the ſide on which its beak is, that, as the vapours condenſe therein, the liquor may run off with eaſe. To the beak of this veſſel fit a receiver: the fumes of the lighted ſulphur will be condenſed, and gather into drops in the head, out of which they will run into the receiver. There, when the Sulphur has done burning, you will find an Acid liquor, which is the Spirit of Sulphur.

OBSERVATIONS.

IN the burning of Sulphur, the Phlogiſton which ſerves for its baſis is diſſipated, and ſeparated from the acid which is left at liberty. The acid fumes which riſe from the lighted ſulphur ſtrike againſt the inſide of the head placed over it, are there condenſed, and appear in the form of a liquor. But as Sulphur, like all other inflammable bodies, Nitre excepted, will not burn in cloſe veſſels, it is neceſſary that the air be freely admitted here; which occaſions the loſs of a great deal of the Acid of the Sulphur, as is evident from the pungent ſuffocating ſmell perceived in the laboratory during the operation.

This Acid, while combined with the Phlogiſton, is incapable of contracting any union with water; but when alone is very apt to mix therewith: it is even proper to put ſome in its way, that it may incorporate therewith as ſoon as it is diſcharged from the Sulphur; for it is then very free from phlegm, very volatile, and conſequently very little diſpoſed to condenſe into a liquor, but, on the contrary, very apt to fly off in vapours. The water, which it imbibes with a kind of avidity, fixes and detains it; ſo that by this means a much greater quantity thereof is obtained from Sulphur, than if it were diſtilled without this precaution.

It is proper, therefore, now and then, to introduce a diſh full of hot water under the head which receives the fumes of the Sulphur. The vapours that exhale from the water bedew the inſide of the head, and procure the advantage we are ſpeaking of.

The ſame thing may be effected ſeveral other ways: thus, the crucible containing the Sulphur may be ſet on a foot placed in an earthen diſh with ſome water in it; which, however, muſt not riſe above the foot; for if it ſhould reach the crucible, it might cool and fix the ſulphur. The diſh thus prepared muſt be placed on a ſand-bath hot enough to make the water ſmoke continually; and over all is to be placed the head as directed in the proceſs.

The ſize and form of the veſſel which immediately receives the ſulphureous fumes may alſo contribute to increaſe the quantity of the Acid Spirit. A very large veſſel, with a hole at bottom no wider than is juſt ſufficient to admit the vapours, is the propereſt for this operation.

After the Sulphur has burnt for ſome time, it often happens that a ſort of ſkin or cruſt forms on its ſurface, which is not inflammable, but gradually leſſens the quantity and vigour of the flame as it increaſes in thickneſs, and at laſt puts it quite out. This cruſt proceeds from the impurities, and heterogeneous uninflammable particles contained in the ſulphur.

phur. Care muſt be taken to remove it with an iron wire as faſt as it forms.

Two quantities of ſulphur may alſo be kept in two crucibles, and heated alternately. That in which the Sulphur is hot and melted may be ſubſtituted for the other in which the Sulphur is grown cold and fixed; becauſe cold Sulphur does not burn well.

The Spirit of Sulphur is at firſt pungent and volatile, becauſe it ſtill retains a ſmall portion of the Phlogiſton: but that ſulphureous part flies off, eſpecially if the bottle in which the Spirit is kept be left for ſome time unſtopped.

The Acid obtained from Sulphur appears by all chymical proofs perfectly like that obtained from Vitriol: they differ in this only, that the former is the pureſt; for the Acid obtained from Vitriol carries over with it ſome metallic parts, as we obſerved before, which can never happen to that obtained from Sulphur.

If linen rags dipped in a ſolution of Fixed Alkali be expoſed to the fumes of burning brimſtone, the Spirit of Sulphur joins with the Alkali, and therewith forms a Vitriolated Tartar. This Salt is known to be formed when the rags grow ſtiff, and appear ſpangled with a vaſt many glittering points, which are nothing but little cryſtals of the Salt we are ſpeaking of.

When the Sulphur burns very gently and ſlowly the Spirit that exhales from it is ſo much the more ſulphureous and volatile: and hence the Salt formed by the combination of this Spirit with the Alkali expoſed to it in linen rags, as in the above-mentioned experiment, is not at firſt a Vitriolated Tartar; but a Neutral Salt of a particular kind, which is capable of being decompoſed by any other Mineral Acid, the ſulphureous Acid having leſs affinity than any of the reſt with Alkalis. Nevertheleſs, this Salt becomes in time a true Vitriolated Tartar, becauſe the ſulphureous part which weakened its Acid eaſily quits it and flies off.

PROCESS VI.

To concentrate the Vitriolic Acid.

TAKE the Vitriolic Acid you intend to concentrate, that is, to dephlegmate and make ſtronger: pour it into a good glaſs retort, of ſuch a ſize that your quantity of Acid may but half fill it: ſet this retort in the ſand-bath of a reverberating furnace: fit to it a receiver; lute it on, and give a gradual fire. There will come over into the receiver a clear liquor, the firſt drops of which will be but faintly acid: this is the moſt aqueous part.

When the drops begin to follow one another much more ſlowly, raiſe your fire, till the liquor begin to bubble a little in the middle. Keep it thus gently boiling, till one half or two thirds thereof be come over into the receiver. Then let your veſſels cool; unlute them; what remains in the retort pour into a cryſtal bottle, and ſtop it exactly with a glaſs ſtopple rubbed with emery.

OBSERVATIONS.

THE Acid obtained from Sulphur is generally very aqueous; either becauſe in preparing it water muſt neceſſarily be adminiſtered, that it may unite therewith as it ſeparates from the Sulphur; or becauſe it is ſo greedy of moiſture as to attract a great deal from the air, which muſt needs be admitted to make the Sulphur burn.

The Acid obtained from Vitriol, excepting that which riſes laſt, is alſo mixed with a pretty conſiderable quantity of phlegm; becauſe the Vitriol, though calcined, ſtill retains a great deal thereof, which riſes with the Acid in diſtillation. Now, as there are many chymical experiments that will not ſucceed without Acids exceedingly dephlegmated, it is proper to have in a laboratory all the Acids thus conditioned; becauſe if they happen to be too ſtrong for particular operations, as is ſometimes the caſe, it is very eaſy to lower them to the deſired degree, by adding a ſufficient quantity of water.

The Vitriolic Acid is much heavier and much leſs volatile than water. If therefore a mixture of theſe two liquors be expoſed to the fire, the aqueous part will riſe with a degree of heat which is not able to carry up the Acid: by this means they may be ſeparated from each other; and thus is the Vitriolic Acid concentrated.

Nevertheleſs, as this Acid combines moſt cloſely with water, and is in a manner ſtrongly connected with it, the water carries up ſome portion thereof along with it; and hence it comes, that the liquor which riſes into the receiver is acid: it is called *Spirit of Vitriol.*

As the fire carries off the moſt aqueous part, the other which remains in the retort increaſes in ſpecific gravity. The Acid particles are brought nearer together, retain the aqueous particles more obſtinately, and therefore to ſeparate them the degree of heat muſt be increaſed.

It is uſual to draw off one half or two thirds of the liquor that was put into the retort: but this depends on the degree of ſtrength the Acid was of before concentration, and the degree of concentration intended to be given it.

If the Acid to be concentrated be Oil of Vitriol, from being brown or black it grows clearer as the operation advances, and at laſt becomes perfectly colourleſs and tranſparent; becauſe the fat matter which tinged it black is diſſipated during the proceſs. Some of it depoſites a white cryſtalline earth.

A ſulphureous ſmell is generally perceived about the veſſels in this operation. This ariſes from a ſmall portion of the Phlogiſton from which the Acid is not free; and it is this inflammable matter which gives the Oil of Vitriol its black colour: for the cleareſt and beſt rectified Oil of Vitriol will become brown, and even black, in a ſhort time, if any inflammable matter, though in a very ſmall quantity, be diſſolved therein.

The veſſels are luted in this operation, to prevent any loſs of the Spirit of Vitriol, which being very acid is of uſe in many chymical experiments, and may itſelf alſo be again concentrated.

We obſerved, that in this operation it is neceſſary the retort ſhould be of very good glaſs. Indeed the Acid is ſo active, and ſo ſtrong, that if the glaſs be tender and have a little too much ſalt in its compoſition, it will be ſo corroded thereby that it will fall to pieces.

Though we directed the retort to be ſet in a ſand-bath for this operation, it does not follow that it may not alſo be placed in a naked fire: on the contray, when the heat is not conveyed through a bath the operation advances faſter, and is much leſs tedious. But then great caution muſt be uſed, and the cloſeſt attention given to the managment of the fire, which muſt be raiſed by almoſt imperceptible degrees, eſpecially at the beginning of the operation; otherwiſe it is next to a certainty that the veſſels will break. In general, a naked fire may be employed in almoſt all diſtillations which require a greater degree of heat than that of boiling water, or the *balneum mariæ*: the operation will be ſooner finiſhed; but it requires an experienced hand, that has by practice acquired a habit of governing the fire with judgment.

There is moreover another advantage in not uſing the ſand-bath; which is, that if in the time of the operation you perceive the fire too fierce, you can quickly check it, either by ſtopping cloſe all the apertures of the furnace, or by drawing out all or part of the lighted coals. This inconvenience is not near ſo eaſily remedied when you uſe the ſand-bath; becauſe when once heated it retains its heat very long after the fire is quite extinguiſhed.

PROCESS VII.

To decompoſe Vitriolated Tartar by means of the Phlogiſton; or to compoſe Sulphur by combining the Vitriolic Acid with the Phlogiſton.

TAKE equal parts of Vitriolated Tartar, and very dry Salt of Tartar, ſeparately reduced to powder; add an eighth part of their weight of charcoal-duſt; and mix the whole together very accurately. Throw this mixture into a red-hot crucible, placed in a furnace filled with burning coals. Cover it very cloſe, and keep it very hot, till the mixture melt, which may be known by uncovering the crucible from time to time. There will then appear a blueiſh flame, accompanied with a pungent ſmell of Sulphur.

Take the crucible out of the fire: diſſolve its contents in hot water: filter the ſolution through brown paper ſupported by a glaſs funnel: drop into the filtered liquor by little and little any Acid whatever. As you add the acid the liquor will grow more and more turbid, and let fall a grey precipitate. Continue dropping in more Acid till the liquor will yield no more precipitate. Filter it a ſecond time, to ſeparate it from the precipitate: what remains on the filter is a true inflammable Sulphur, which you may either melt or ſublime into flowers.

OBSERVATIONS.

ALL bodies that contain the Vitriolic Acid may contribute, as well as Vitriolated Tartar, to the generation of Sulphur: ſo that all the neutral ſalts in which this Acid is a principle, the Alums, Selenites, Gypſums, Vitriols, may be ſubſtituted for it in this experiment. All theſe matters, with the addition of charcoal-duſt only, being fuſed in a crucible, conſtantly produce Sulphur; becauſe the Vitriolic Acid having a greater affinity with the Phlogiſton than with any thing elſe, will quit its baſis, whatever it be, to join with the Phlogiſton of the charcoal, and therewith form a Sulphur.

The fixed Alkali added thereto helps to promote the fuſion of the ingredients, which is neceſſary for effecting the deſired combination. It alſo ſerves to unite with the Sulphur, when formed; and thus makes the combination called *Liver of Sulphur*, which prevents the Sulphur from being conſumed as ſoon as formed: for the fixed Alkalis, which are incombuſtible, hinder Sulphur from burning ſo eaſily as it would do if they were not joined with it. They may afterwards be ſeparated from each other, by the means of any Acid whatever.

This proceſs, in which Sulphur is regenerated by re-combining together the principles of which it was originally compoſed, is one of the moſt beautiful experiments that modern Chymiſtry hath produced. We are indebted for it to M. Stahl; and Dr. Geoffroy hath given a particular account of it in the Memoirs of the Academy of Sciences.

Before theſe gentlemen Glauber and Boyle had indeed publiſhed methods of producing Sulphur, Glauber made uſe of his *Sal mirabile* and powdered charcoal: Boyle employed the Vitriolic Acid and Oil of Turpentine. But neither of thoſe Chymiſts underſtood the true theory of their operations: they did not thoroughly know the principles of Sulphur: they did not imagine they had compoſed Sulphur: they thought they only extracted what they ſuppoſed to exiſt previouſly in the matters they employed in their experiments.

M. Stahl was the firſt who diſcovered and explained the nature of Sulphur, and proved that in Glauber's and Boyle's experiments Sulphur was actually produced, by uniting together the principles of which it is conſtituted. This beautiful experiment gives the ſtrongeſt luſtre of evidence to the theory of the compoſition of that mixt, which acts ſuch a capital part in Chymiſtry; and it can no longer be doubted, that Sulphur is actually a combination of the Vitriolic Acid with the Phlogiſton.

Beſides this important truth, our proceſs for compoſing Sulphur by art proves ſeveral others that are equally eſſential and fundamental.

The firſt is, that the Vitriolic Acid hath a greater affinity with the Phlogiſton than with any other thing, ſeeing it quits metallic and earthy ſubſtances, as well as Alkaline ſalts, in order to combine therewith.

The ſecond is, that Sulphur combines with fixed Alkalis without ſuffering any decompoſition; ſeeing it may be ſeparated from them entire and unaltered; and ſeeing that very Sulphur, which is naturally indiſſoluble in water, is rendered ſoluble therein by the union it hath contracted with the fixed alkali.

The third is, that the Vitriolic Acid, which, when it is pure, hath the greateſt affinity with Alkalis of any Acid whatever, loſes a great deal of that affinity by contracting an union with the Phlogiſton; ſeeing the weakeſt acids are capable of decompoſing the Liver of Sulphur, and ſeparating the Sulphur from the Alkali. And this alſo confirms one of the general propoſitions concerning affinities advanced in our theory; to wit, that the affinities of compound or mixed ſubſtances are weaker than thoſe of the ſame ſubſtances in a purer or more ſimple ſtate.

CHAP. II.

Of the NITROUS ACID.

PROCESS I.

To extract Nitre out of nitrous Earths and Stones. The Purification of Salt-petre. Mother of Nitre. Magneſia.

TAKE any quantity of nitrous earths or ſtones; reduce them to powder; and therewith mix a third part of the aſhes of green-wood and quick-lime. Put this mixture into a barrel or vat, and pour on it hot water to about twice the weight of the whole maſs. Let it ſtand thus for twenty-four hours, ſtirring it from time to time with a ſtick. Then filter the liquor through brown paper, or paſs it through a flannel bag, till it come clear: it will then have a yellowiſh colour. Boil this liquor, and evaporate till you perceive that a drop of it let fall on any cold body coagulates. Then ſtop the evaporation, and ſet your liquor in a cool place. In the ſpace of four and twenty hours cryſtals will be formed in it, the figure of which is that of an hexagonal priſm, having its oppoſite planes generally equal, and terminated at each extremity by a pyramid of the ſame number of ſides. Theſe cryſtals will be of a browniſh colour, and deflagrate on a live coal.

Decant the liquor from theſe cryſtals; mix it with twice its weight of hot water; evaporate and cryſtallize as before. Repeat the ſame operation till the liquor will yield no more cryſtals: it will then be very thick, and goes by the name of *Mother of Nitre.*

OBSERVATIONS.

EARTHS and ſtones that have been impregnated with animal or vegetable juices ſuſceptible of putrefaction, and have been long expoſed to the air, but ſheltered from the ſun and rain, are thoſe which yield the greateſt quantity of Nitre. But all ſorts of earths and ſtones are not equally fit to produce it. None is ever found in flints or ſands of a cryſtalline nature.

Some earths and ſtones abound ſo with Nitre, that it effloreſces ſpontaneouſly on their ſurface, in the form of a cryſtalline down. This Nitre may be collected with brooms, and accordingly has the name of *Salt-petre Sweepings.* Some of this ſort is brought from India.

Hitherto we are much in the dark as to the origin and generation of Nitre. Some Chymiſts pretend that the Nitrous Acid is diffuſed through the air, and gradually depoſited in ſuch earths and ſtones as are qualified to receive it.

Others, conſidering that none of it is ever obtained but from earths that have been impregnated with vegetable or animal juices, have from thence concluded thoſe two kingdoms to be the general repoſitories of the Nitrous Acid; that if we do not perceive it to exiſt in ſuch matters at all, or at leaſt in any great quantity, till they have undergone putrefaction, and are in ſome meaſure incorporated with ſuitable earths and ſtones, it is becauſe the Acid is ſo entangled with heterogeneous particles that it requires the aſſiſtance of putrefaction, and much more of filtration through an earth, to diſengage it, and enable it to appear in its proper nature.

Laſtly, others are of opinion that this Acid is no other than the univerſal or Vitriolic Acid; diſguiſed indeed by a portion of the Phlogiſton, which is combined with it in a peculiar manner by the means of putrefaction. They ground this opinion chiefly on the analogy or reſemblance which they find between the Nitrous Acid and the Volatile Sulphureous Spirit. Its volatility, its pungent ſmell, its properties of taking fire, and of deſtroying the blue and violet colours of vegetables, ſerve them as ſo many proofs.

Their opinion is the more probable on this account, that even though the Nitrous Acid ſhould actually be produced by vegetable and animal ſubſtances, yet as theſe ſubſtances themſelves draw all their component principles from the earth, and as the Vitriolic Acid is diffuſed through all the ſoils which afford them nouriſhment, there is great reaſon to think that the Nitrous Acid is no other than the Vitriolic Acid altered by the changes and combinations it hath undergone in its paſſage into and through thoſe ſubſtances. In 1750 the Royal Academy of Sciences at Berlin propoſed an account of the generation of Nitre as the ſubject for their prize, which was conferred on a Memoir wherein this laſt opinion was ſupported by ſome new and very judicious experiments.

The proceſs by which our Salt-petre makers extract Nitre in quantities, out of rubbiſh and nitrous earths, is very nearly the ſame with that here ſet down; ſo that I ſhall not enter into a particular account of it. I ſhall only take notice of one thing, which it is of ſome conſequence to know; namely, that there is no nitrous earth which does not contain ſea-ſalt alſo. The greateſt quantities of this ſalt are to be found in thoſe earths which have been drenched with urine, or other animal excrements. Now as the rubbiſh of old houſes in great cities is in this claſs, it comes to paſs that when the Salt-petre workers evaporate a nitrous lixivium drawn from that rubbiſh, as ſoon as the evaporation is brought to a certain pitch, a great many little cryſtals of ſea-ſalt form in the liquor, and fall to the bottom of the veſſel.

The Salt-petre workers in France call theſe ſaline particles *the Grain*, and take care to ſeparate them from the liquor (which, as long as it continues hot, keeps the ſalt-petre diſſolved) before they ſet it to cryſtallize. This fact ſeems a little ſingular, conſidering that ſea-ſalt diſſolves in water more eaſily than ſalt-petre, and cryſtallizes with more difficulty.

In order to diſcover the cauſe of this phenomenon, we muſt recollect ſome truths delivered in our theoretical Elements. The firſt is, that water can keep but a determinate quantity of any ſalt in ſolution, and that if water fully ſaturated with a ſalt be evaporated, a quantity of ſalt will cryſtallize in proportion to the quantity of water evaporated. The ſecond is, that thoſe ſalts which are the moſt ſoluble in water, particularly thoſe which run in the air, will diſſolve in cold and in boiling water equally; whereas much greater quantities of the other ſalts will diſſolve in hot and boiling water than in cold water. Theſe things being admitted, when we know that ſea-ſalt is one of the firſt ſort, and ſalt-petre of the ſecond, the reaſon why ſea-ſalt precipitates in the preparation of ſalt-petre appears at once. For

When the ſolution of Salt-petre and Sea-ſalt comes to be evaporated to ſuch a degree that it contains as much Sea-ſalt as it poſſibly can, this ſalt muſt begin to cryſtallize, and continue to do ſo gradually as the evaporation advances. But becauſe at the ſame time it does not contain as much ſalt-petre as it can hold, ſeeing it is capable of diſſolving a much greater quantity thereof when it is boiling hot than when it is cold, this laſt-named ſalt will not cryſtallize ſo ſoon. If the evaporation were continued till the caſe of the Salt-petre came to be the ſame with that of the Sea-ſalt, then the ſalt-petre alſo would begin to cryſtallize gradually in proportion to the water evaporated, and the two ſalts will continue cryſtallizing promiſcuouſly together: but it is never carried ſo far; nor is it ever neceſſary: for, as the water cools, it becomes more and more incapable of holding in ſolution the ſame quantity of ſalt-petre as when it was boiling hot.

And then comes the very reverſe, with regard to the cryſtallizing of the two ſalts; for then the Salt-petre ſhoots, and not the Sea-ſalt. The reaſon of this fact alſo is founded on what has juſt been ſaid. The Sea-ſalt, of which cold water will diſſolve as much as boiling water, and which owed its cryſtallizing before only to the evaporation, now ceaſes to cryſtallize as ſoon as the evaporation ceaſes; while the Salt-petre, which the water kept diſſolved only becauſe it was boiling hot, is forced to cryſtallize merely by the cooling of the water.

When the ſolution of Salt-petre has yielded as many cryſtals of that Salt as it can yield by cooling, it is again evaporated, and being then ſuffered to cool yields more cryſtals. And thus they continue evaporating and cryſtallizing, till the liquor will afford no more cryſtals. It is plain that as the Salt-petre cryſtallizes, the proportion of Sea-ſalt to the diſſolving liquor increaſes; and as a certain quantity of water evaporates alſo during the time employed in cryſtallizing the Salt-petre, a quantity of Sea-ſalt, proportioned to the water ſo evaporating, muſt cryſtallize in that time: and this is the reaſon why Salt-petre is adulterated with a mixture of Sea-ſalt. It likewiſe follows that the laſt cryſtals of Nitre, obtained from a ſolution of Salt-petre and Sea-ſalt, contain much more Sea-ſalt than the firſt.

From all that has been ſaid concerning the cryſtallization of Salt-petre and Sea-ſalt, it is eaſy to deduce the proper way of purifying the former of theſe two Salts from a mixture of the latter. For this purpoſe the Salt-petre to be refined need only be diſſolved in fair water. The proportion between the two ſalts in this ſecond ſolution is very different from what it was in the former; for it contains no more Sea-ſalt than what had cryſtallized along with the Salt-petre under favour of the evaporation, the reſt having been left diſſolved in the liquor that refuſed to yield any more nitrous cryſtals.

As there is therefore a much greater quantity of Salt-petre than of Sea-ſalt in this ſecond ſolution, it is eaſy to evaporate it to ſuch a degree that a great deal of Salt-petre ſhall cryſtallize, while much more of the water muſt neceſſarily be evaporated before any of the Sea-ſalt will cryſtallize.

However, the Salt-petre is not yet entirely freed from all mixture of Sea-ſalt by this firſt purification; for the cryſtals obtained from this liquor, in which Sea-ſalt is diſſoved, are ſtill encruſted, and, as it were, infected therewith: hence it comes, that, to refine the Salt-petre thoroughly, theſe cryſtallizations muſt be repeated four or five times.

The Salt-petre men commonly content themſelves with cryſtallizing it thrice, and call the produce Salt-petre of the firſt, ſecond, or third ſhoot, according to the number of cryſtallizations it has undergone. But their beſt refined Salt-petre, even that of the third ſhooting, is not yet ſufficiently pure for Chymical experiments that require much accuracy: ſo that it muſt be further purified; but ſtill by the ſame method.

The Nitrous Acid is not pure in the earths and ſtones from which it is extracted. It is combined partly with the very earth in which it is formed, and partly with the Volatile Alkali produced by the putrefaction of the vegetable or animal matters that concurred to its generation. A Fixed Alkali and Quick-lime are added to the lixivium of a nitrous earth, in order to decompoſe the nitrous Salt formed in that earth, and to ſeparate the Acid from the Volatile Alkali and the abſorbent earth with which it is united: thence comes that copious ſediment which appears in the lye at the beginning of the evaporation. Theſe matters form with that Acid a true Nitre, much more capable than the original Nitrous Salts of cryſtallization, detonation, and the other properties which are eſſential thereto. The baſis of Nitre is therefore a Fixed Alkali mixed with a little lime.

The Mother of Nitre, which will yield no more cryſtals, is brown and thick: by evaporation over a fire it is further inſpiſſated, and becomes a dry, ſolid body; which, however, being left to itſelf ſoon gives, and runs into a liquor. This water ſtill contains a good deal of Nitre, Sea-ſalt, and the Acids of theſe Salts united with an abſorbent earth. It contains moreover a great deal of a fat, viſcid matter, which prevents its cryſtallizing.

All ſaline ſolutions in general, after having yielded a certain quantity of cryſtals, grow thick, and refuſe to part with any more, though they ſtill contain much Salt. They are all called *Mother-waters*, as well as that which hath yielded Nitre. The Mother-waters of different Salts may prove the ſubjects of curious and uſeful inquiries.

If a Fixed Alkali be mixed with the Mother of Nitre, a copious white precipitate immediately falls, which being collected and dried is called *Magneſia*. This precipitate is nothing but the abſorbent earth that was united with the Nitrous Acid, together with a good deal of the lime that was added, and was alſo united with that Acid, from which they are now ſeparated by the Fixed Alkali, according to the uſual laws of affinities.

The Vitriolic Acid poured upon Mother of Nitre cauſes many Acid vapours to riſe, which are a compound of the Nitrous and Marine Acids, that is, an *Aqua Regia*. On this occaſion alſo there falls a large quantity of a white powder, which is ſtill called *Magneſia;* yet it differs from the former in that it is not, like it, a pure abſorbent earth, but combined with the Vitriolic Acid.

An *Aqua regis* may alſo be drawn from nitrous earths by the force of fire only, without the help of any additament.

PROCESS II.

To decompoſe Nitre by means of the Phlogiſton. Nitre fixed by Charcoal. Clyſſus *of Nitre.* Sal Polychreſtum.

TAKE the pureſt Salt-petre in powder; put it into a large crucible, which it may but half fill; ſet the crucible in a common furnace, and ſurround it with coals. When it is red-hot the Nitre will melt, and become as fluid as water. Then throw into the crucible a ſmall quantity of charcoal-duſt: the Nitre and the Charcoal will immediately deflagrate with violence; and a great commotion will be raiſed, accompanied with a conſiderable hiſſing, and abundance of black ſmoke. As the charcoal waſtes, the detonation will abate, and ceaſe entirely as ſoon as the coal is quite conſumed.

Then throw into the crucible the ſame quantity of charcoal-duſt as before, and the ſame phenomena will be repeated. Let this coal alſo be conſumed: then add more, and go on in the ſame manner till you can excite no further deflagration; always obſerving to let the burning coal be entirely conſumed before you add any freſh. When no deflagration enſues, the matter contained in the crucible will have loſt much of its fluidity.

OBSERVATIONS.

Nitre will not take fire, unleſs the inflammable matter added to it be actually burning, or the Nitre itſelf red-hot, and ſo thoroughly ignited, as immediately to kindle it. Therefore, if you would procure the detonation of Nitre with charcoal, and make uſe of cold charcoal, as in the proceſs, the Nitre in the crucible muſt be red-hot, and in perfect fuſion: but you may alſo uſe live coals, and then the Nitre need not be red-hot.

It is proper that the crucible uſed in this experiment ſhould be only half full; for during the detonation its contents ſwell, and might run over without this precaution. For the ſame reaſon the charcoal-duſt is to be thrown in by little and little; and that firſt put in muſt be entirely conſumed before any freſh be added.

The matter remaining in the crucible after the operation is a very ſtrong Fixed Alkali. Being expoſed to the air it quickly attracts the moiſture thereof, and runs into a liquor. It is called *Alkalizated Nitre*, or, to diſtinguiſh it from Nitre alkalizated by other inflammable matters, *Nitre fixed by charcoal.*

However, this Alkali is not abſolutely pure. It ſtill contains a portion of the Nitre that hath not been decompoſed. For when there remains but a little of this ſalt mixed with a great quantity of Alkali, which is not inflammable, the Alkali in ſome meaſure ſhelters it, coats it over, and obſtructs that immediate contact with the inflammable matters applied, which is neceſſary to make it deflagrate.

If

If the Fixed Alkali be deſired perfectly free from any mixture of undecompoſed Nitre, the fire about the crucible muſt be conſiderably increaſed as ſoon as the detonation is entirely over; the matter muſt be made to flow, which requires a much ſtronger heat than would melt Nitre, and kept thus in fuſion for about an hour. After this no perfect Nitre will be found therein: for the little that was left, being unable to abide the force of the fire, as not being extremely fixed, either is entirely diſſipated, or loſes its Acid, which is carried off by the violence of the heat.

Fixed Nitre contains alſo a portion of the earth that conſtituted the baſis of the Nitre, which is no other than the lime employed in its cryſtallization, or elſe ſome of the earth with which its Acid was originally combined, and which it retained in cryſtallizing. When Nitre is deflagrated with ſuch matters as produce aſhes, theſe aſhes likewiſe furniſh a certain quantity of earth, which mixes with the Fixed Alkali. To ſeparate theſe ſeveral earths from the Alkali, nothing more is requiſite than to let it run *per deliquium*, or to diſſolve it in water, and filter the ſolution through brown paper. Whatever is ſaline will paſs through the filtre with the water, and the earthy part will be left upon it.

The Nitrous Acid is not only diſſipated during the deflagration of the Nitre, but is even deſtroyed, and perfectly decompoſed. The ſmoke that riſes during the operation has not the leaſt odour of an Acid. Its nature may be accurately examined by catching it in proper veſſels, and condenſing it into a liquor.

Nitre differs from Sulphur, and from all other inflammable bodies whatever, in this, that the free acceſs of the air is indiſpenſably neceſſary to make any of the others burn; whereas Nitre, and Nitre only, is capable of burning in cloſe veſſels: and this property furniſhes us with the means of collecting the vapours which it diſcharges in deflagration.

For this purpoſe, to a tubulated earthen retort you muſt fit two or three large adopters: ſet the retort in a furnace; and under it make a fire ſufficient to keep its bottom moderately red. Then take a ſmall quantity, two or three pinches for example, of a mixture of three parts of Nitre with one of charcoal-duſt, and drop it into the retort through its tube, which muſt be uppermoſt, and immediately ſtopped cloſe. A detonation inſtantly enſues, and the vapours that riſe from the inflamed mixture of Nitre and charcoal, paſſing out through the neck of the retort into the adopters, circulate therein for a while, and at laſt condenſe into a liquor.

When the detonation it over, and the vapours condenſed, or nearly ſo, drop into the retort another equal quantity of the mixture; and repeat this till you find there is liquor enough in the recipients to be examined with eaſe and accuracy. This liquor is almoſt inſipid, and ſhews no tokens of acidity; or at moſt but very ſlight ones. It is called *Clyſſus* of Nitre.

It is eaſy to perceive why ſeveral adopters are required in this experiment, and why a very ſmall quantity of the mixture muſt be introduced into the retort at once. The exploſion, and the quantity of air and vapours diſcharged on this occaſion, would quickly burſt the veſſels, if all theſe precautions were not attended to. This plainly appears from the terrible effects of gun-powder, which is nothing but a compoſition of Nitre, Sulphur, and Charcoal.

Nitre is alſo decompoſed and takes fire by the means of Sulphur; but the circumſtances and the reſult differ widely from thoſe produced therewith by charcoal, or any other inflammable body.

Nitre deflagrates with Sulphur on account of the Phlogiſton which the latter contains. If one part of Sulphur be mixed with two or three parts of Nitre, and the mixture thrown by little and little into a red-hot crucible, upon every projection there ariſes a detonation accompanied with a vivid flame.

The vapours diſcharged on this occaſion have the mingled ſmell of a Sulphureous Spirit and Spirit of Nitre; and if they be collected by means of a tubulated retort, and ſuch an apparatus of veſſels as was uſed in the preceding experiment, the liquor contained in the recipients is found to be an actual mixture of the Acid of Sulphur, the Sulphureous Spirit, and the Acid of Nitre; the firſt being in greater quantity than the other two, and the ſecond greater than the laſt.

Nor is the remainder after detonation a Fixed Alkali, as in the former experiments; but a Neutral Salt, conſiſting of the Acid of Sulphur combined with the Alkali of Nitre; a ſort of Vitriolated Tartar known in medicine by the name of *Sal Polychreſtum*.

There are evidently two eſſential differences between this laſt experiment and the preceding one. What remains after the deflagration of Nitre with Sulphur is not a Fixed Alkali: and, moreover, the vapours emitted in the operation are impregnated with a quantity of the Nitrous Acid; which is not the caſe when Nitre is decompoſed by any other inflammable matter which contains no Vitriolic Acid.

The reaſon of theſe differences is naturally deducible from what hath been already ſaid concerning the properties of the Vitriolic and Nitrous Acids. We have ſeen that by burning Sulphur its Acid is not decompoſed, but only ſeparated from its Phlogiſton. We alſo know, that its Acid has a great affinity with Fixed Alkalis. Theſe things being granted, it follows that, as ſoon as the Nitrous Acid quits its Alkaline baſis, by deflagrating with the Phlogiſton of the Sulphur, the Acid of this very Sulphur, being ſet at liberty by that deflagration, muſt unite with the Alkaline baſis deſerted by the Acid of Nitre, and therewith form a Neutral Salt. Hence, inſtead of a Fixed Alkali, we find at the end of the operation a ſort of Vitriolated Tartar; the Acids of Sulphur and of Vitriol being the ſame, as is evident from what hath been above ſaid concerning them.

In order to diſcover the cauſe of the other phenomenon, we muſt recollect two things advanced in our Elements of the Theory; to wit, that the affinity of the Vitriolic Acid with Fixed Alkalis is greater than that of the Nitrous Acid; and again, that the Nitrous Acid is not capable of combining and taking fire with the Phlogiſton, but when it is in the form of a Neutral Salt, that is, when it is united with ſome alkaline, earthy, or metallic baſis. If theſe two principles be applied to the effect in queſtion, the ſolution is eaſy and natural. For, in the deflagration of Nitre with Sulphur, the Phlogiſton is not the only ſubſtance capable of ſeparating the Nitrous Acid from its baſis: the Acid of the Sulphur, more and more of which is ſet at liberty as the Phlogiſton is conſumed, is alſo capable of producing the ſame effect; but with this difference, that the portion of the Nitrous Acid which is detached from its Alkali by the Phlogiſton is at the ſame inſtant ſet on fire and decompoſed by that union; whereas the portion thereof which is ſeparated by the Vitriolic Acid, being when ſo ſeparated incapable of uniting with the Phlogiſton, and of conſuming therewith, is preſerved entire, and riſes in vapours, together with that portion of the Vitriolic Acid which could not unite with the baſis of the Nitre.

PROCESS

PROCESS III.

To decompoſe Nitre by means of the Vitriolic Acid. The Smoking Spirit of Nitre. Sal de duobus. *The Purification of Spirit of Nitre.*

TAKE equal parts of well purified Nitre and Green Vitriol: dry the Nitre thoroughly, and bruiſe it to a fine powder. Calcine the Vitriol to redneſs: reduce it likewiſe to a very fine powder; and mingle theſe two ſubſtances well together. Put the mixture into an earthen long-neck, or a good glaſs retort coated, of ſuch a ſize that it may be but half full.

Set this veſſel in a reverberating furnace covered with its dome; apply a large glaſs receiver, having a ſmall hole in its body, ſtopped with a little lute. Let this receiver be accurately luted to the retort with the fat lute, and the joint covered with a ſlip of canvas ſmeared with lute made of quick-lime and the white of an egg. Heat the veſſels very gradually. The receiver will ſoon be filled with very denſe red vapours, and drops will begin to diſtil from the noſe of the retort.

Continue the diſtillation, increaſing the fire a little when you obſerve the drops to follow each other but ſlowly, ſo that above two thirds of a minute paſſes between them; and, in order to let out the redundant vapours, open the ſmall hole in the receiver from time to time. Towards the end of the operation raiſe the fire ſo as to make the retort red. When you find that, even when the retort is red-hot, nothing more comes over, unlute the receiver, and without delay pour the liquor it contains into a cryſtal bottle, and cloſe it with a cryſtal ſtopple ground in its neck with emery. This liquor will be of a reddiſh yellow colour, ſmoking exceedingly, and the bottle containing it will be conſtantly filled with red fumes like thoſe obſerved in the receiver.

OBSERVATIONS.

THE Vitriolic Acid having a greater affinity with Fixed Alkalis than with any other ſubſtance, the Phlogiſton excepted, and being in the Vitriol united with a ferruginous baſis, will naturally quit that baſis to join with the Fixed Alkali of the Nitre; the Acid whereof being weaker than the Vitriolic,

lic, as we have already obſerved on ſeveral occaſions, muſt needs be thereby expelled from its baſis. The Nitre therefore is decompoſed by the Vitriol, and its Acid being ſet at liberty, is carried up by the force of the fire.

Indeed the Nitrous Acid, being thus ſeparated from its alkaline baſis, might be expected to combine with the ferruginous baſis of the Vitriol: but as it has, like all other Acids, much leſs affinity with Metallic ſubſtances than with Alkalis, even a moderate degree of fire is ſufficient to ſeparate it from them. Moreover, this Acid hath either no effect, or very little, upon iron that has loſt much of its Phlogiſton by contracting an union with any Acid; which is the caſe of the ferruginous baſis of Vitriol.

By the proceſs here delivered a very ſtrong, perfectly dephlegmated, and vaſtly ſmoking Spirit of Nitre is obtained. If the precautions of drying the Nitre and calcining the Vitriol be neglected, the Acid that comes over, greedily attracting the water contained in theſe ſalts, will be very aqueous, will not ſmoke, and will be almoſt colourleſs, with a very ſlight tinge of lemon.

The fumes of highly concentrated Spirit of Nitre, ſuch as that obtained by the above proceſs, are light, corroſive, and very dangerous to the lungs; being no other than the moſt dephlegmated part of the Nitrous Acid. The perſon therefore who unlutes the veſſels, or pours the liquor out of the receiver into the bottle, ought with the greateſt caution to avoid drawing them in with his breath; and for that reaſon ought to place himſelf ſo that a current of air, either natural or artificial, may carry them off another way. It is alſo neceſſary that care be taken, during the operation, to give the vapours a little vent every now and then, by opening the ſmall hole in the recipient; for they are ſo elaſtic, that, if too cloſely confined, they will burſt the veſſels.

When the operation is over, you will find a red maſs at the bottom of the retort, caſt, as it were, in a mould. This is a Neutral Salt of the nature of Vitriolated Tartar, reſulting from the union of the Acid of the Vitriol with the Alkaline baſis of the Nitre.

The ferruginous baſis of the Vitriol, which is mixed with this ſalt, gives it the red colour. To ſeparate it therefrom, you muſt pulveriſe it, diſſolve it in boiling water, and filter the ſolution ſeveral times through brown paper; becauſe the ferruginous earth of the Vitriol is ſo fine, that ſome of it will paſs through the firſt time. When the ſolution is very clear, and depoſites no ſediment, let it be ſet to ſhoot, and it will yield cryſtals of Vitriolated Tartar; to which Chymiſts have given the peculiar title of *Sal de duobus*.

In this *Caput mortuum* we frequently find, beſides the ferruginous earth of Vitriol, a portion of Nitre and Vitriol not decompoſed; either becauſe the two ſalts were not thoroughly mingled, or becauſe the fire was not raiſed high enough towards the end of the operation.

Nitre may alſo be decompoſed, and its acid obtained, by the interpoſition of any of the other Vitriols, Alums, Gypſums, Boles, Clays; in ſhort, by means of any compound in which the Vitriolic Acid is found, provided it have not a Fixed Alkali for its baſis.

The diſtillers of *Aqua fortis*, who make large quantities at a time, and who uſe the leaſt chargeable methods, do their buſineſs by the means of earths impregnated with the Vitriolic Acid; ſuch as Clays and Boles. With theſe earths they accurately mix the Nitre from which they intend to draw their Spirit: this mixture they put into large oblong earthen pots, having a very ſhort curved neck, which enters a recipient of the ſame matter and form. Theſe veſſels they place in two rows oppoſite to each other in long furnaces, and cover them over with bricks cemented with Windſor-loam, which ſerves for a reverberatory: then they light the fire in the furnace, making it at firſt very ſmall, only to warm the veſſels; after which they throw in wood, and raiſe the fire till the pots grow quite red-hot, in which degree they keep it up till the diſtillation is entirely finiſhed.

The Acid of Nitre may alſo be ſeparated from its baſis by means of the pure Vitriolic Acid. For this purpoſe the Nitre from which you mean to extract the Acid muſt be finely pulverized, put into a glaſs retort, and a third of its weight of concentrated Oil of Vitriol poured on it: the retort muſt be placed in a reverberating furnace, and a receiver, like that uſed in the preceding operation, expeditiouſly applied.

As ſoon as the Oil of Vitriol touches the Nitre the mixture grows hot, and copious red fumes begin to appear: ſome drops of the Acid come over even before the fire is kindled in the furnace.

On this occaſion the fire muſt be moderate; becauſe the Vitriolic Acid, being clogged by no baſis, acts upon the Nitre much more briſkly, and with much greater effect, than when it is not pure.

This operation may be performed by a ſand-heat; which is a ſpeedy and commodious way of obtaining the Nitrous Acid. In other reſpects the precautions recommended in the preceding experiment muſt be carefully obſerved here, both in diſtilling the Acid and in taking it out of the receiver.

The Spirit of Nitre extracted by this method is as ſtrong, and ſmokes as much, as that obtained by calcined Vitriol, provided the Oil of Vitriol made uſe of be well concentrated; but it is generally tainted by the admixture of a ſmall portion of the Vitriolic Acid, which, having no baſis of its own to reſtrain it, is carried up by the heat before it can lay hold of the baſis of the Nitre.

There are ſeveral experiments in Chymiſtry that ſucceed equally well whether the Nitrous Acid be or be not thus adulterated with a mixture of the Vitriolic Acid; but there are ſome, as we ſhall ſee, that will not ſucceed without a Spirit of Nitre ſo mixed. If the Acid be diſtilled with a view to ſuch experiments, it muſt be kept as it is. But moſt experiments require the Spirit of Nitre to be abſolutely pure; and if it be intended for ſuch, it muſt be perfectly cleanſed from the Vitriolic taint.

This is eaſily effected by mixing your Spirit with very pure Nitre, and diſtilling it a ſecond time. The Vitriolic Acid, with which this Spirit of Nitre is adulterated, coming in contact with a great quantity of undecompoſed Nitre, unites with its Alkaline baſis, and expels a proportionable quantity of the Nitrous Acid.

In the retort made uſe of to diſtil the Nitrous Acid, by means of the pure Vitriolic Acid, is found a *Caput mortuum*, differing from that left after the diſtillation of the ſame Acid by the interpoſition of Vitriol, in as much as it contains no red ferruginous earth. This is a very white ſaline maſs, moulded in the bottom of the retort: if you pound it, diſſolve it in boiling water, and evaporate the ſolution, it will ſhoot into cryſtals of Vitriolated Tartar: ſometimes alſo it contains a portion of undecompoſed Nitre, which ſhoots after the Vitriolated Tartar, becauſe it is much more ſoluble in water.

CHAP. III.

Of the MARINE ACID.

PROCESS I.

To extract Sea-ſalt from Sea-water, and from Brine-ſprings. Epſom Salt.

FILTER the ſalt-water from which you intend to extract the ſalt: evaporate it by boiling till you ſee on its ſurface a dark pellicle: this conſiſts wholly of little cryſtals of ſalt juſt beginning to ſhoot: now ſlacken the fire, that the brine may evaporate more ſlowly, and without any agitation. The cryſtals, which at firſt were very ſmall, will become larger, and form hollow truncated pyramids, the apices whereof will point downwards, and their baſes be even with the ſurface of the liquor.

Theſe pyramidal cryſtals are only collections of ſmall cubical cryſtals concreted into this form. When they have acquired a certain magnitude they fall to the bottom of the liquor. When they come to be in ſuch heaps as almoſt to reach the ſurface of the liquor, decant it from them, and continue the evaporation till no more cryſtals of Sea-ſalt will ſhoot.

OBSERVATIONS.

THE Acid of Sea-ſalt is ſcarce ever found, either in ſea-water or in the earth, otherwiſe than united with a fixed alkali of a particular kind, which is its natural baſis; and conſequently it is in the form of a Neutral Salt. This ſalt is plentifully diſſolved in the waters of the ocean, and when obtained therefrom bears the name of *Sea-ſalt*. It is alſo found in the earth in vaſt cryſtalline maſſes, and is then called *Sal-gem:* ſo that Sea-ſalt and Sal-gem are but one and the ſame ſort of ſalt, differing very little from each other, except as to the places where they are found.

In the earth are alſo found ſprings and fountains, whoſe waters are ſtrong brines, a great deal of Sea-ſalt being diſſolved in them. Theſe ſprings either riſe directly from the ſea, or run through ſome mines of Sal-gem, of which they take up a quantity in their paſſage.

As the ſame, or at leaſt nearly the ſame, quantity of Sea-ſalt will continue diſſolved in cold water as boiling water will take up, it cannot ſhoot, as Nitre does, by the mere cooling of the water in which it is diſſolved: it cryſtallizes only by the means of evaporation, which continually leſſens the proportion of the water to the ſalt; ſo that it is always capable of containing juſt ſo much the leſs Sea-ſalt the more there is cryſtallized.

The brine ſhould not boil after you perceive the pellicle of little cryſtals beginning to form on its ſurface; for the calmneſs of the liquor allows them to form more regularly, and become larger. Nor after this ſhould the evaporation be hurried on too faſt; for a ſaline cruſt would form on the liquor, which, by preventing the vapours from being carried off, would obſtruct the cryſtallization.

If the evaporation be continued after the liquor ceaſes to yield any cryſtals of Sea-ſalt, other cryſtals will be obtained of an oblong four-ſided form, which have a bitter taſte, and are almoſt always moiſt. This ſort of ſalt is known by the name of *Epſom Salt*, which it owes to a ſalt ſpring in England, from the water of which it was firſt extracted. This ſalt, or rather ſaline compound, is a congeries of Glauber's ſalt and Sea-ſalt, in a manner confounded together, and mixed with ſome of the Mother of Sea-ſalt, in which is contained a kind of bituminous matter. Theſe two Neutral Salts, which conſtitute the Epſom Salt, may be eaſily ſeparated from each other, by means of cryſtallization only. Epſom Salt is purgative and bitter; and therefore named *Sal Catharticum Amarum*, or bitter purging Salts.

There are different methods uſed in great works for obtaing Sea-ſalt out of water in which it is diſſolved. The ſimpleſt and eaſieſt is that practiſed in France, and in all thoſe countries which are not colder. On the ſea-ſhore they lay out a ſort of broad ſhallow pits, pans, or rather ponds, which the ſea fills with the tide of flood. When the ponds are thus filled, they ſtop their communication with the ſea, and leave the water to evaporate by the heat of the ſun; by which means all the ſalt contained in it neceſſarily cryſtallizes. Theſe pits are called *Salt Ponds*. Salt can be made in this way in the ſummer-time only; at leaſt in France, and other countries of the ſame temperature: for during the winter, when the ſun has leſs power and rains are frequent, this method is not practicable.

For this reaſon, as it often rains in the province of Normandy, the inhabitants take another way to extract Salt from ſea-water. The labourers employed for this purpoſe raiſe heaps of ſand on the ſhore, ſo that the tide waters and drenches them when it flows, and leaves the ſand dry when it ebbs. During the interval between two tides of flood the ſun and the air eaſily carry off the moiſture that was left, and ſo the ſand remains impregnated with all the ſalt that was contained in the evaporated water. Thus they let it acquire as much ſalt as it can by ſeveral returns of flood, and then waſh it out with freſh water, which they evaporate over a fire in leaden boilers.

To obtain the Salt from brine-ſprings, the water need only be evaporated: but as ſeveral of theſe ſprings contain too little ſalt to pay the charges that would be incurred, if the evaporation were effected by the force of fire only, the manufacturers have fallen upon a leſs expenſive method of getting rid of the greateſt part of the water, and preparing the brine for cryſtallization, in much leſs time, and with much leſs fire, than would otherwiſe have been neceſſary.

The method conſiſts in making the water fall from a certain heighth on a great many ſmall ſpars of wood, which divide it into particles like rain. This is performed under ſheds open to all the winds, which paſs freely through this artificial ſhower. By this means the water preſents to the air a great extent of ſurface, being indeed reduced almoſt entirely to ſurface, and the evaporation is carried on with great eaſe and expedition. The water is raiſed by pumps to the heighth from which it is intended to fall *.

PROCESS II.

Experiments concerning the decompoſition of Sea-ſalt, by means of the Phlogiſton. Kunckel's *Phoſphorus.*

" OF pure urine that has fermented five or ſix days take " a quantity in proportion to the quantity of phoſ- " phorus you intend to make: it requires about one third

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* The Marquis de Montalembert, in a Memoir read before the Academy of Sciences, propoſes a new method of effecting theſe evaporations, together with ſome conſiderable improvements in the ſtructure and diſpoſition of the buildings neceſſary for that purpoſe. They are called by the French *Batiments de Graduation;* which may properly enough be rendered *Brine-houſes.*

" part of a hogſhead to make a dram of Phoſphorus. Evaporate it in iron pans, till it become clotted, hard, black, and nearly like chimney-ſoot; at which time it will be reduced to about a ſixtieth part of its original weight before evaporation.

" When the urine is brought to this condition put it in ſeveral portions into ſo many iron pots, under which you muſt keep a pretty briſk fire ſo as to make their bottoms red, and ſtir it inceſſantly till the volatile ſalt and the fetid oil be almoſt wholly diſſipated, till the matter ceaſe to emit any ſmoke, and till it ſmell like peach-bloſſoms. Then put out the fire, and pour on the matter, which will now be reduced to a powder, ſomewhat more than twice its weight of warm water. Stir it about in this water, and leave it to ſoak therein for twenty-four hours. Pour off the water by inclination; dry the drenched matter, and pulverize it. The previous calcination carries off from the matter about a third of its weight, and the lixiviation waſhes out half the remainder.

" With what remains thus calcined, waſhed, and dried, mix half its weight of gravel, or yellow freeſtone raſped, having ſifted out and thrown away all the fineſt particles. River ſand is not proper on this occaſion, becauſe it flies in a hot fire. Then add to this mixture a ſixteenth part of its weight of charcoal, made of beech, or of any other wood except oak, becauſe that alſo flies. Moiſten the whole with as much water as will bring it to a ſtiff paſte, by working and kneading it with your hands: now introduce it into your retort, taking care not to daub its neck. The retort muſt be of the beſt earth, and of ſuch a ſize, that when your matter is in it, a full third thereof ſhall ſtill be empty.

" Place your retort, thus charged, in a reverberating furnace, ſo proportioned, that there may be an interval of two inches all round between the ſides of the furnace and the bowl of the retort, even where it contracts to form the neck, which ſhould ſtand inclined at an angle of ſixty degrees. Stop all the apertures of the furnace, except the doors of the fire-place and aſh-hole.

" Fit on to the retort a large glaſs ballon two thirds full of water, and lute them together, as in diſtilling the Smoking Spirit of Nitre. In the hinder part of this ballon, a little above the ſurface of the water, a ſmall hole muſt be bored. This hole is to be ſtopped with a ſmall peg of birch-wood, which muſt ſlip in and out very eaſily,

“ and have a ſmall knob to prevent its falling into the ballon. This peg is to be pulled out from time to time, that by applying the hand to the hole it may be known whether the air, rarefied by the head of the retort, iſſues out with too much or too little force.

“ If the air ruſhes out with too much rapidity, and with a hiſſing noiſe, the door of the aſh hole muſt be entirely ſhut, in order to ſlacken the fire. If it do not ſtrike pretty ſmartly againſt the hand, that door muſt be opened wider, and large coals thrown into the fire-place to quicken the fire immediately.

“ The operation uſually laſts four and twenty hours; and the following ſigns ſhew that it will ſucceed, provided the retort reſiſt the fire.

“ You muſt begin the operation with putting ſome unlighted charcoal in the aſh-hole, and a little lighted charcoal at the door thereof, in order to warm the retort very ſlowly. When the whole is kindled, puſh it into the aſh-hole, and cloſe the door thereof with a tile. This moderate heat brings over the phlegm of the mixture. The ſame degree of fire muſt be kept up four hours, after which ſome coals may be laid on the grate of the fire-place, which the fire underneath will kindle by degrees. With this ſecond heat brought nearer the retort, the ballon grows warm, and is filled with white vapours, which have the ſmell of fetid oil. In four hours after, this veſſel will grow cool and clear; and then you muſt open the door of the aſh-hole one inch, throw freſh coals into the fire-place every three minutes, and every time ſhut the door of it, leſt the cold air from without ſhould ſtrike againſt the bottom of the retort and crack it.

“ When the fire has been kept up to this degree for about two hours, the inſide of the ballon begins to be netted over with a volatile ſalt of a ſingular nature, which cannot be driven up but by a very violent fire, and which ſmells pretty ſtrong of peach-kernels. Care muſt be taken that this concrete ſalt do not ſtop the little hole in the ballon: for in that caſe it would burſt, the retort being then red-hot, and the air exceedingly rarefied. The water in the ballon, being heated by the vicinity of the furnace, exhales vapours which diſſolve this ſprigged ſalt, and the ballon clears up in half an hour after it has ceaſed riſing.

“ In about three hours from the firſt appearance of this ſalt, the ballon is again filled with new vapours, which

“ ſmell like Sal Ammoniac thrown upon burning coals. “ They condenſe on the ſides of the receiver into a ſalt “ which is not branched like the former, but appears in “ long perpendicular ſtreaks, which the vapours of the wa- “ ter do not diſſolve. Theſe white vapours are the fore-run- “ ners of the Phoſphorus, and a little before they ceaſe to “ riſe they loſe their firſt ſmell of Sal Ammoniac, and ac- “ quire the odour of garlic.

“ As they aſcend with great rapidity, the little hole muſt “ be frequently opened, to obſerve whether the hiſſing be “ not too ſtrong: for, in that caſe, it would be neceſſary to “ ſhut the door of the aſh-hole quite cloſe. Theſe white “ vapours continue two hours. When you find they ceaſe “ riſing, making a ſmall paſſage through the dome, by “ opening ſome of its regiſters, that the flame may juſt be- “ gin to draw. Keep up the fire in this mean ſtate till the “ firſt volatile Phoſphorus begin to appear.

“ This appears in about three hours after the white va- “ pours firſt begin to riſe. In order to diſcover it, pull out “ the little birchen peg once every minute, and rub it a- “ gainſt ſome hot part of the furnace, where it will leave a “ trail of light, if there be any Phoſphorus upon it.

“ Soon after you obſerve this ſign, there will iſſue out “ through the little hole of the ballon a ſtream of blueiſh “ light, which continues of a greater or ſhorter extent to the “ end of the operation. This ſtream or ſpout of light does “ not burn. If you hold your finger againſt it for twenty “ or thirty ſeconds, the light will adhere to it; and if you “ rub that finger over your hand, the light will beſmear it, “ and render it luminous.

“ But from time to time this ſtreamer darts out to the “ length of ſeven or eight inches, ſnapping and emitting “ ſparks of fire; and then it burns all combuſtible bodies “ that come in its way. When you obſerve this, you muſt “ manage the fire very warily, and ſhut the door of the aſh- “ hole quite cloſe, yet without ceaſing to throw coals into “ the fire-place every two minutes.

“ The Volatile Phoſphorus continues two hours; after “ which the little ſpout of light contracts to the length of a “ line or two: and now is the time for puſhing your fire to “ the utmoſt: immediately ſet the door of the aſh-hole wide “ open, throw billets of wood into it, unſtop all the regi- “ ſters of the reverberatory, ſupply the fire-place with large “ coals every minute; in ſhort, for ſix or ſeven hours all the inſide of the furnace muſt be kept of a white heat, ſo that the retort ſhall not be diſtinguiſhable.

“ In this fierce extremity of heat the true Phoſphorus diſtils like an oil, or like melted wax: one part thereof floats on the water in the recipient, the other falls to the bottom. At laſt, the operation is known to be quite over when the upper part of the ballon, in which the volatile Phoſphorus appears condenſed in a blackiſh film, begins to grow red: for this ſhews that the Phoſphorus is burnt where the red ſpot appears. You muſt now ſtop all the regiſters, and ſhut all the doors of the furnace, in order to ſmother the fire; and then cloſe up the little hole in the ballon with fat lute or bees-wax. In this condition the whole muſt be left for two days; becauſe, the veſſels muſt not be ſeparated till they are perfectly cold, leſt the Phoſphorus ſhould take fire.

“ As ſoon as the fire is out, the ballon, which is then in the dark, preſents a moſt agreeable object: all the empty part thereof above the water ſeems filled with a beautiful blue light: which continues for ſeven or eight hours, or as long as the ballon keeps warm, never diſappearing till it is cooled.

“ When the furnace is quite cold take out the veſſels, and ſeparate them from each other as neatly as poſſible. With a linen cloth wipe away all the black ſtuff you find in the mouth of the ballon; for if that filth ſhould mix with the Phoſphorus, it would hinder it from being tranſparent when moulded. This muſt be done with great expedition: after which pour into the ballon two or three quarts of cold water, to accelerate the precipitation of the Phoſphorus that ſwims at top. Then agitate the water in the ballon, to rinſe out all the Phoſphorus that may ſtick to the ſides: pour out all the water thus ſhaken and turbid, into a very clean earthen pan, and let it ſtand till it grows clear. Then decant this firſt uſeleſs water, and on the blackiſh ſediment, left at the bottom of the pan, pour ſome boiling water to melt the Phoſphorus; which thereupon unites with the fuliginous matter, or volatile Phoſphorus, that precipitated with it, both together forming a maſs of the colour of ſlate. When this water, in which you have melted the Phoſphorus, is cool enough, take out the Phoſphorus, throw it into cold water, and therein break it into little bits in order to mould it.

“ Then take a matras, having a long neck ſomewhat wider next the body than at its mouth: cut off half the

" body, ſo as to make a funnel of the neck-part, the ſmaller end of which muſt be ſtopped with a cork. The firſt mould being thus prepared, plunge it endwiſe, with its mouth uppermoſt, in a veſſel full of boiling water, and fill it with that water. Into this funnel throw the little bits of your ſlate-like maſs, which will melt again in this hot water, and fall ſo melted to the bottom of the tube. Stir this melted matter with an iron wire, to promote the ſeparation of the Phoſphorus from the fuliginous matter with which it is fouled, and which, being leſs ponderous than the Phoſphorus, will gradually riſe above it towards the upper part of the cylinder.

" Keep the water in the veſſel as hot as at firſt, till, on taking out the tube, you ſee the Phoſphorus clean and tranſparent. Let the clear tube cool a little, and then ſet it in cold water, where the Phoſphorus will congeal as it cools. When it is perfectly congealed, pull out the cork, and with a ſmall rod, near as big as the tube, puſh the cylinder of Phoſphorus towards the mouth of the funnel, where the feculency lies. Cut off the black part of the cylinder, and keep it apart: for when you have got a quantity thereof, you may melt it over again in the ſame manner, and ſeparate the clean Phoſphorus which it ſtill contains. As to the reſt of the cylinder which is clean and tranſparent, if you intend to mould it into ſmaller cylinders, you may cut it in ſlices, and melt it again by the help of boiling water in glaſs tubes of ſmaller dimenſions."

OBSERVATIONS.

THIS proceſs for making Phoſphorus is copied from the Memoirs of the Academy of Sciences for the Year 1737; where it is deſcribed by M. Hellot, with ſo much accuracy, clearneſs, and preciſion, that I thought I could not do better than tranſcribe it, without departing from the author's own expreſſions, for the ſake of ſuch as may not have thoſe Memoirs. We ſhall take occaſion, in theſe obſervations, to point out ſome eſſential circumſtances which I have omitted in the deſcription of the Proceſs, that I might not break the connection between the phenomena that happen in the courſe of this experiment.

It is proper to obſerve, in the firſt place, that one of the moſt uſual cauſes of miſcarriage in this operation is a defect of the requiſite qualities in the retort employed. It is abſolutely neceſſary to have that veſſel made of the beſt earth, and ſo well made that it ſhall be capable of reſiſting the utmoſt violence of fire, continued for a very long time; as appears by the deſcription of the proceſs. The retorts commonly ſold by potters, and other earthen-ware men, are not fit for this operation; and M. Hellot was obliged to ſend to Heſſe-Caſſel for ſuch as he wanted.

We ſhall, in the ſecond place, obſerve with M. Hellot, that, "before you ſet your retort in the furnace, it is proper "to make an eſſay of your matter, to ſee if there be reaſon "to hope for ſucceſs. For this purpoſe put about an ounce "thereof into a ſmall crucible, and heat it till the veſſel be "red. The mixture, after having ſmoked, ought to chop "or crack without puffing up, or even riſing in the leaſt. "From theſe cracks will iſſue undulating flames, white and "blueiſh, darting upwards with rapidity. This is the firſt "volatile Phoſphorus, which occaſions all the danger of the "operation. When theſe firſt flaſhes are over, increaſe the "heat of your matter by laying a large live coal upon the "crucible. You will then ſee the ſecond Phoſphorus, like "a luminous, ſteady vapour, of a colour inclining to violet, "covering the whole ſurface of the matter: it continues "for a very long time, and diffuſes a ſmell of garlic, which "is the diſtinguiſhing odour of the Phoſphorus you are ſeeking.

"When this luminous vapour is entirely gone, pour the "red hot matter out of the crucible upon an iron plate. If "you do not find one drop of ſalt in fuſion, but that, on "the contrary, the whole falls readily into powder, it is a "proof that your matter was ſufficiently lixiviated, and that "it contains no more fixed Salt, or Sea-ſalt, if you will, "than is requiſite. If you find on the plate a drop of ſalt "coagulated, it ſhews that there is too much left in, and "that there is danger of your miſcarrying in the operation; "becauſe the redundant ſalt would corrode, and eat through "the retort. In this caſe your matter muſt be waſhed again, "and then ſufficiently dried."

Our third obſervation ſhall be concerning the furnace proper to be employed in this operation. This furnace muſt be ſo conſtructed, that, within a narrow compaſs it may give a heat at leaſt equal to that of a glaſs-houſe furnace, or rather greater, eſpecially during the laſt ſeven or eight hours of the operation. M. Hellot in his Memoir gives an exact deſcription of ſuch a furnace.

" As certain accidents may happen in the courſe of the
" operation, ſome precautions are to be taken againſt them.
" For inſtance, if the ballon ſhould break while the Phoſphorus is diſtilling, and any of it ſhould fall on combuſtible bodies, it would ſet them on fire, and probably burn
" the laboratory, becauſe it is not to be extinguiſhed without
" the greateſt difficulty. The furnace muſt therefore be
" erected under ſome vault, or upon a bed of brick-work
" raiſed under ſome chimney that draws well: nor muſt
" any furniture or utenſil of wood be left near it. If a little flaming Phoſphorus ſhould fall on a man's legs or
" hands, in leſs than three minutes it would burn its way
" to the very bone. In ſuch a caſe nothing but urine will
" ſtop its progreſs.

" If the retort crack while the Phoſphorus is diſtilling,
" there is an unſucceſsful end of your operation. It is eaſy
" to perceive this by the ſtink of garlic which you will
" ſmell about the furnace; and moreover, the flame that
" iſſues through the apertures of the reverberatory will be of
" a beautiful violet colour. The Acid of Sea-ſalt always
" gives this colour to the flame of ſuch matters as are burnt
" along with it. But if the retort break before the Phoſphorus hath made its appearance, its contents may be
" ſaved by throwing a number of cold bricks into the fireplace, and upon them a little water to quench the fire at
" once." All theſe uſeful obſervations we owe alſo to
M. Hellot.

The Phoſphorus here deſcribed was firſt diſcovered by a citizen of Hamburgh, named Brandt, who worked upon urine in ſearch of the Philoſopher's ſtone. Afterwards two other ſkilful Chymiſts, who knew nothing more of the proceſs, than that Phoſphorus was obtained from urine, or, in general, from the human body, likewiſe endeavoured to diſcover it; and each of them ſeparately did actually make the diſcovery. Theſe two Chymiſts were Kunckel and Boyle.

The former perfected the diſcovery, and found out a method of making it in conſiderable quantities at a time; which occaſioned it to be called *Kunckel's Phoſphorus*. The other, who was an Engliſh gentleman, had not time to bring his diſcovery to perfection, and contented himſelf with lodging a voucher of his having diſcovered it in the hands of the Secretary of the Royal Society of London, who gave him a certificate thereof.

“ Though Brandt,” ſays M. Hellot, “ who had before this ſold his ſecret to a Chymiſt named Krafft, ſold it afterwards to ſeveral other perſons, and even at a very low rate; and though Mr. Boyle publiſhed the proceſs for making it; yet it is extremely probable that both of them kept in their own hands the maſter-key; I mean, *the particular management neceſſary to make the operation ſucceed:* for, till Kunckel found it out, no other Chymiſt ever made any conſiderable quantity thereof, except Mr. Godfrey Hankwitz, an Engliſh Chymiſt, to whom Mr. Boyle revealed the whole myſtery.

“ Nevertheleſs,” continues he, “ we are very far from alledging that all thoſe who have deſcribed this operation meaned to impoſe upon the world: but we conceive that moſt of them having obſerved luminous vapours in the ballon, and ſome ſparks about the juncture of the veſſels, were contented with thoſe appearances. And thus it came to paſs, that, after Kunckel and Boyle died, Mr. Godfrey Hankwitz was the only Chymiſt that could ſupply Europe therewith; on which account it is likewiſe very well known by the name of *Engliſh Phoſphorus.*”

Almoſt all the Chymiſts conſider Phoſphorus as a ſubſtance conſiſting of the Acid of Sea-ſalt combined with the Phlogiſton, in the ſame manner as Sulphur conſiſts of the Vitriolic Acid combined with the Phlogiſton. This opinion is founded on the following principles.

Firſt, Urine abounds with Sea-ſalt, and contains alſo a great deal of Phlogiſton; now theſe are the ingredients of which they conjecture Phoſphorus to be compoſed.

Secondly, Phoſphorus has many of the properties of Sulphur; ſuch as being ſoluble in oils; melting with a gentle heat; being very combuſtible; burning without any ſoot; giving a vivid and blueiſh flame; and laſtly, leaving an acid liquor when burnt: ſenſible proofs that it differs from Sulphur in nothing but the nature of its Acid.

Thirdly, this Acid of Phoſphorus, being mixed with a ſolution of ſilver in Spirit of Nitre, precipitates the ſilver, and this precipitate is a true *Luna cornea,* which appears to be more volatile even than the common ſort; as M. Hellot tells us, who made the experiment. This fact proves inconteſtably that the Acid of Phoſphorus is of the ſame nature with that of Sea-ſalt: for all Chymiſts know that the property of precipitating ſilver in a *Luna cornea* belongs to the Marine Acid only.

Fourthly, M. Stahl obſerves, that, if Sea-ſalt be caſt on live coals, they inſtantly burn with great activity; then they emit a very vivid flame, and are much ſooner conſumed than if none of this ſalt had touched them; that Sea-ſalt in ſubſtance, which will bear the violence of fire a conſiderable time when fuſed in a crucible, without ſuſtaining any ſenſible diminution, yet evaporates very quickly, and is reduced to white flowers, by the immediate contact of burning coals; and, laſtly, that the flame which riſes on this occaſion is of a blue colour inclining to violet, eſpecially if it be not thrown directly on the coals themſelves, but kept in fuſion amidſt burning coals, in a crucible ſo placed that the vapour of the Salt may join with the enflamed Phlogiſton as it riſes from the coals.

Theſe experiments of M. Stahl's prove, that the Phlogiſton acts upon the acid of Sea-ſalt, even while it is combined with its alkaline baſis. The flame that appears on this occaſion may be conſidered as an imperfect Phoſphorus: and indeed its colour is exactly like that of Phoſphorus.

All the facts above related evince, that the Acid of Phoſphorus is a-kin to that of Sea-ſalt; or rather that it is the very ſame. But there are other facts which prove that this Acid undergoes ſome change at leaſt, ſome peculiar preparation, before it enters into the compoſition of a true Phoſphorus, and that, when extricated therefrom by burning, it is not a pure Acid of Sea-ſalt, but is ſtill adulterated with a mixture of ſome other ſubſtance, which makes it conſiderably different from that Acid. For theſe obſervations we are obliged to M. Marggraff, of the Academy of Sciences at Berlin, a celebrated Chymiſt. I ſhall preſently give an account of his principal experiments as ſuccinctly as poſſible.

M. Marggraff hath alſo publiſhed a proceſs for making Phoſphorus, and aſſures us, that by means thereof we may obtain in leſs time, with leſs heat, leſs trouble, and leſs expence, a greater quantity of Phoſphorus than by any other method. His operation is this:

He takes two pounds of Sal Ammoniac in powder, which he mixes accurately with four pounds of Minium. This mixture he puts into a glaſs retort, and with a graduated fire draws off a very ſharp, volatile, urinous ſpirit.

We obſerved in our theoretical Elements, that ſome metallic ſubſtances have the property of decompoſing Sal Ammoniac, and ſeparating its volatile Alkali; concerning which phenomenon we there gave our opinion. Minium, which is a calx of lead, is one of thoſe metallic ſubſtances. In this experiment it decompoſes the Sal Ammoniac, and ſeparates its volatile Alkali; what remains in the retort is a combination of the Minium with the Acid of the Sal Ammoniac, which is well known to be the ſame with the Marine Acid; and conſequently the reſidue of this operation is a ſort of *Plumbum corneum*.

The quantity thereof is four pounds eight ounces. Of this he mixes three pounds with nine or ten pounds of urine, that has ſtood putrefying for two months, evaporated to the conſiſtence of honey. Theſe he mixes by little and little in an iron pan over the fire, ſtirring the mixture from time to time. Then he adds half a pound of charcoal-duſt, and evaporates the matter, kept continually ſtirring, till the whole be brought to a black powder. He next diſtils the mixture in a glaſs retort with degrees of fire, which he raiſes towards the end ſo as to make the retort red-hot, in order to expel all the urinous ſpirit, ſuperfluous oil, and ammoniacal ſalt. The diſtillation being finiſhed, there remains nothing in the retort but a very friable *caput mortuum*.

This remainder he pulveriſes again, and throws a pinch thereof on live coals, thereby to diſcover whether or no the matter be rightly prepared, and in order for yielding Phoſphorus. If it be ſo, it preſently emits an arſenical odour, and a blue undulating flame, which paſſes over the ſurface of the coals like a wave.

Being thus aſſured of the ſucceſs of his operation, he puts one half of his matter in three equal parts, into three ſmall earthen German retorts, capable of holding about eighteen ounces of water a-piece. Theſe three retorts, none of which is above three quarters full, he places together in one reverberatory furnace, built much like thoſe we have deſcribed, except that it is ſo conſtructed as to hold the three retorts diſpoſed in one line. To each retort he lutes a recipient ſomething more than half full of water, ordering the whole in ſuch a manner, that the noſes of his retorts almoſt touch the ſurface of the water.

He begins the diſtillation with warming the retorts ſlowly, for about an hour, by a gentle heat. When that time is elapſed he raiſes the fire gradually, ſo that in half an hour more the coals begin to touch the bottoms of the retorts. He continues throwing coals into the furnace by little and little, till they riſe half way the heighth of the retorts; and in this he employs another half hour. Laſtly, in the next half hour he raiſes the coals above the bowls of the retorts.

Then the Phoſphorus begins to aſcend in clouds: on this he inſtantly increaſes the heat of the fire as much as poſſible, filling the furnace quite up with coals, and making the retorts very red. This degree of fire cauſes the Phoſphorus to diſtil in drops, which fall to the bottom of the water. He keeps up this intenſe heat for an hour and half, at the end of which the operation is finiſhed; ſo that it laſts but four hours and an half in all: nay, he further aſſures us, that an artiſt well verſed in managing the fire, may perform it in four hours only. In the ſame manner he diſtils the ſecond moiety of his mixture in three other ſuch retorts.

The advantage he finds in making uſe of ſeveral ſmall retorts, inſtead of a ſingle large one, is, that the heat penetrates them with more eaſe, and the operation is peformed with leſs fire, and in leſs time. He purifies and moulds his Phoſphorus much in the ſame manner as M. Hellot does. From the quantity of ingredients above-mentioned, he obtains two ounces and a half of fine cryſtalline moulded Phoſphorus.

M. Marggraff conſidering, as a conſequence of the experiments above related, that a highly concentrated Acid of Sea-ſalt contributes greatly towards the formation of Phoſphorus, proceeded to try ſeveral other experiments, in which he employed that Acid in a ſtate of combination with other baſes. He mixed, for inſtance, an ounce of *Luna cornea* with an ounce and half of putrefied and inſpiſſated urine, and from the mixture obtained a very beautiful Phoſphorus.

In ſhort, the ſeveral experiments mentioned having thoroughly perſuaded him that the Acid of Sea-ſalt, provided it were highly concentrated, would combine with the Phlogiſton as readily as the Vitriolic Acid does, he reſolved to try whether he could not make Phoſphorus with matters containing that Acid and the Phlogiſton, without making uſe of any urine.

With this view he made a great number of different trials, wherein he employed Sea-ſalt in ſubſtance, Sal Ammoniac, Plumbum corneum, Luna cornea, fixed Sal Ammoniac, otherwiſe called *Oil of Lime*. Theſe ſeveral ſubſtances, all of which contain the Acid of Sea-ſalt, he mixed with ſundry matters abounding in Phlogiſton, different vegetable coals, and even animal matters, ſuch as the oil of hartſhorn, human blood, *&c.* varying the proportions of theſe ſubſtances many different ways, without ever being able to produce a ſingle atom of Phoſphorus: which gave this able Chymiſt juſt cauſe to ſuſpect, that the Marine Acid, while pure and crude, is not capable of combining with the Phlogiſton in the manner requiſite to form a Phoſphorus; that for this purpoſe it is neceſſary the Acid ſhould have contracted a previous union with ſome other matter; and that the Acid found in urine hath probably undergone the neceſſary change. M. Marggraff is of opinion that the matter, which by its union renders the Marine Acid capable of entering into the compoſition of Phoſphorus, is a ſort of exceedingly ſubtile vitrifiable earth. The experiments he made upon the Acid of Phoſphorus, will ſhew that his notion is not altogether groundleſs. M. Marggraff having let ſome urine, evaporated to the conſiſtence of honey, ſtand quiet in a cool place, obtained from it, by cryſtallization, a Salt of a ſingular nature. By diſtilling this urine afterwards, he ſatisfied himſelf that it yielded him much leſs Phoſphorus than urine from which no Salt had been extracted; and as it cannot be entirely deprived of this Salt, he thinks that the ſmall quantity of Phoſphorus, which this urine yielded him, came from the Salt that was ſtill left in it.

Further, he diſtilled this ſalt ſeparately with lamp-black, and obtained from it a conſiderable quantity of very fine Phoſphorus. He even mixed *Luna cornea* with this Salt, in order to ſee whether it would not increaſe the quantity of his Phoſphorus; but without ſucceſs: whence he concluded, that in this Saline matter reſides the true Acid that is fit to enter into the compoſition of Phoſphorus. This opinion is confirmed by ſeveral experiments on the Acid of Phoſphorus, which he found to have ſome properties reſembling thoſe of this Salt.

The Acid of Phoſphorus ſeems to be more fixed than any other: and therefore if you would ſeparate it, by burning, from the Phlogiſton with which it is united, there is no occaſion for ſuch an apparatus of veſſels as is employed for obtaining the Spirit of Sulphur. For this Acid will remain at the bottom of the veſſel in which you burn your Phoſphorus: indeed, if it be urged by the force of fire, its moſt ſubtile part evaporates, and the remainder appears in the form of a vitrified matter.

This Acid effervesces with fixed and volatile Alkalis, and therewith forms Neutral Salts; but very different from Sea-ſalt, and from Sal Ammoniac. That which has a fixed Alkali for its baſis does not crackle when thrown on burning coals; but ſwells and vitrifies like Borax. That which has a volatile Alkali for its baſis ſhoots into long pointed cryſtals; and, being urged by fire in a retort, lets go its volatile alkali, a vitrified matter remaining behind. This Salt is like that above-mentioned, as obtained from urine and yielding Phoſphorus.

It appears from the experiments adduced, that the Acid of Phoſphorus tends always to vitrification; which proves that it is not pure, and gave M. Marggraff cauſe to think that it is altered by the admixture of a very ſubtile vitrifiable earth.

M. Marggraff alſo obtained Phoſphorus from ſeveral vegetable ſubſtances which we uſe every day for food. This gives him occaſion to conjecture, that the Salt requiſite to the formation of Phoſphorus exiſts in vegetables, and paſſes from thence into the animals that feed upon them.

Laſtly, he concludes his diſſertation by informing us of a very important truth, *viz.* That the Acid obtained from Phoſphorus, by burning it, will ſerve to form Phoſphorus anew; for which purpoſe it need only be combined with ſome charred coal, ſuch as lamp-black, and diſtilled.

From what hath been ſaid on this ſubject it is plain, that the Chymiſts have a great many curious and intereſting inquiries to make concerning Phoſphorus, and particularly concerning its Acid.

I ſhall conclude this article with an account of certain properties of Phoſphorus which I have not yet mentioned.

Phoſphorus diſſolves by lying expoſed to the air. What water cannot effect, ſays M. Hellot, or at leaſt requires eight or ten years to bring about, the moiſture of the air accompliſhes in ten or twelve days; whether it be that the Phoſphorus takes fire in the air, and the inflammable part evaporating, almoſt entirely, leaves the Acid of the Phoſphorus naked, which, like all other Acids, when exceedingly concentrated, is very greedy of moiſture; or elſe that the moiſture of the air, being water divided into infinitely fine particles, is ſo ſubtile as to find its way through the pores of the Phoſphorus, into which the groſſer particles of common water can by no means inſinuate themſelves.

Phoſphorus heated by the vicinity of fire, or by being any way rubbed, ſoon takes fire and burns fiercely. It is ſoluble in all Oils and in Ether, giving to thoſe liquors the property of appearing luminous when the bottle containing the ſolution is opened. Being boiled in water, it likewiſe communicates thereto this luminous quality. M. Morin, Profeſſor at Chartres, is the author of this obſervation.

The late Mr. Groſſe, a celebrated Chymiſt of the Academy of Sciences, obſerved, that Phoſphorus being diſſolved in eſſential oils cryſtallizes therein. Theſe cryſtals take fire in the air, either when thrown into a dry veſſel, or wrapt up in a piece of paper. If they be dipped in Spirit of Wine, and taken out immediately, they do not afterwards take fire in the air: they ſmoke a little, and for a very ſhort time, but hardly waſte at all. Though ſome of them were left in a ſpoon for a fortnight, they did not ſeem to have loſt any thing of their bulk: but when the ſpoon was warmed a little they took fire, juſt like common Phoſphorus that had never been diſſolved and cryſtallized in an eſſential Oil.

M. Marggraff, having put a dram of Phoſphorus, with an ounce of highly concentrated Spirit of Nitre, into a glaſs retort, obſerved, that, without the help of fire, the Acid diſſolved the Phoſphorus; that part of the Acid came over into the recipient which was luted to the retort; that, at the ſame time, the Phoſphorus took fire, burnt furiouſly, and burſt the veſſels with exploſion. Nothing of this kind happens when any of the other Acids, though concentrated, are applied to Phoſphorus.

PROCESS III.

To decompoſe Sea-ſalt by means of the Vitriolic Acid. Glauber's Salt. The Purification and Concentration of Spirit of Salt.

PUT the Sea-ſalt from which you mean to extract the Acid into an unglazed earthen pipkin, and ſet it amidſt live coals. The Salt will decrepitate, grow dry, and fall into a powder. Put this decrepitated Salt into a tubulated glaſs retort, leaving two thirds thereof empty. Set the retort in a reverberating furnace; apply a receiver like that uſed in diſtilling the Smoking Spirit of Nitre, and lute it on in the ſame manner, or rather more exactly if poſſible. Then through the hole, in the upper convexity of the retort, pour a quantity of highly concentrated Oil of Vitriol, equal in weight to about a third part of your Salt, and immediately ſhut the hole very cloſe with a glaſs ſtopple, firſt ground therein with emery ſo as to fit it exactly.

As ſoon as the Oil of Vitriol touches the Salt, the retort and receiver will be filled with abundance of white vapours; and ſoon after, without lighting any fire in the furnace, drops of a yellow liquor will diſtil from the noſe of the retort. Let the diſtillation proceed in this manner without fire, as long as you perceive any drops come: afterwards kindle a very ſmall fire under the retort, and continue diſtilling and raiſing the fire by very ſlow degrees, and with great caution, to the end of the diſtillation; which will be finiſhed before you have occaſion to make the retort red-hot. Unlute the veſſels, and without delay pour the liquor, which is a very ſmoking Spirit of Salt, out of the receiver into a cryſtal bottle, like that directed for the ſmoking Spirit of Nitre.

OBSERVATIONS.

SEA-SALT, as hath been already ſaid, is a Neutral Salt compoſed of an Acid, which differs from thoſe of Vitriol and Nitre, combined with a fixed Alkali that has ſome peculiar properties; but does not vary from the others in its affinities. This Salt therefore, as well as Nitre, muſt be decompoſed by the Vitriolic Acid; which accordingly is the caſe in the proceſs here deſcribed. The Vitriolic Acid unites with the Alkaline baſis of the Sea-ſalt, and ſeparates its Acid; and that with much greater facility than it expels the Nitrous Acid from its Alkaline baſis, becauſe the Acid of Sea-ſalt has not ſo great an affinity as the Nitrous Acid with Fixed Alkalis.

As a highly concentrated Oil of Vitriol is uſed on this occaſion, and as the Sea-ſalt is previouſly dried and decrepitated, the Acid obtained from it by diſtillation is very free from phlegm, and always ſmokes, even more violently than the ſtrongeſt Acid of Nitre. The vapours of this Acid are alſo much more elaſtic and more penetrating than thoſe of the Nitrous Acid: on which account this diſtillation of the ſmoking Spirit of Salt is one of the moſt difficult, moſt laborious, and moſt dangerous operations in Chymiſtry.

This proceſs requires a tubulated retort, that the Oil of Vitriol may be mixed with the Sea-ſalt after the receiver is well luted to the retort, and not before: for, as ſoon as theſe two matters come together, the Spirit of Salt ruſhes out with ſo much impetuoſity, that, if the veſſels were not luted at the time, the copious vapours that would iſſue through the neck of the ballon would ſo moiſten it, as well as the neck of the retort, that it would be impracticable to apply the lute and ſecure the joint as the operation requires. Moreover, the operator would be expoſed to thoſe dangerous fumes, which, on this occaſion, ruſh out, and enter the lungs, with ſuch incredible activity as to threaten inſtant ſuffocation.

Having ſaid ſo much of the elaſticity and activity of the fumes of Spirit of Salt, it is needleſs to inſiſt upon the neceſſity of giving vent to the veſſels from time to time, by opening the little hole of the ballon: indeed the beſt way to prevent the loſs of a great many vapours, on this occaſion, is to employ adopters, and cover them with wet canvas, which will cool and condenſe the vapours they contain.

When the operation is finiſhed, we find a white, ſaline maſs at the bottom of the retort as in a mould. If this maſs be diſſolved in water, and the ſolution cryſtallized, it yields a conſiderable quantity of Sea-ſalt that hath not been decompoſed, and a Neutral Salt conſiſting of the Vitriolic Acid united with the Alkaline baſis of that part which hath been decompoſed. This Neutral Salt, which bears the name of *Glauber* its inventor, differs from Vitriolated Tartar, or the *Sal de duobus*, which remains after diſtilling the Nitrous Acid, eſpecially in that it is more fuſible, more ſoluble in water, and hath its cryſtals differently figured. But as in theſe two Salts the Acid is the ſame, the differences that appear between them muſt be attributed to the peculiar nature of the baſis of Sea-ſalt.

Spirit of Salt drawn by the proceſs above deſcribed is tainted with a ſmall mixture of the Vitriolic Acid, carried up by the force of fire before it had time to combine with the Alkali of the Sea-ſalt; which happens likewiſe to the Nitrous Acid procured in the ſame manner. If you deſire to have it pure, and abſolutely free from the Acid of Vitriol, it muſt be diſtilled a ſecond time from Sea-ſalt, as the Acid of Nitre was before directed to be diſtilled again from freſh Nitre, in order to purify it from any Vitriolic taint.

Sea-ſalt, as well as Nitre, may be decompoſed by any combination of the Vitriolic Acid with a metallic or earthy ſubſtance: but it is proper to obſerve, that if you diſtil Spirit of Salt by means of Green Vitriol, the operation will not ſucceed ſo well as when Spirit of Nitre is diſtilled in the ſame manner: leſs Spirit is obtained, and a much fiercer fire is required.

The cauſe of this lies in the property which the Acid of Sea-ſalt poſſeſſes of diſſolving Iron, even when deprived of a part of its Phlogiſton by having contracted an union with another Acid; ſo that it is no ſooner diſlodged from its own baſis by the Vitriolic Acid, than it unites with the ferruginous baſis of the Vitriol, from which it cannot be ſeparated but by a moſt violent fire. This is the conſequence more eſpecially when calcined Vitriol is made uſe of: for moiſture, as we ſhall preſently ſee, greatly facilitates the ſeparation of the Marine Acid from thoſe ſubſtances with which it is united.

When you do not deſire a highly dephlegmated and ſmoking Spirit of Salt, you may diſtil with the additament of any earth containing the Vitriolic Acid; as Clay, for inſtance, or Bole. To this end one part of Sea-ſalt, ſlightly dried and reduced to a fine powder, muſt be accurately mingled with two parts of the earth you intend to employ likewiſe pulverized; of this mixture make a ſtiff paſte with a proper quantity of rain water, and having formed little balls thereof about the ſize of a hazel nut, let them dry in the ſun; when dry, put them into a ſtone or coated glaſs retort, leaving a third part thereof empty; ſet this veſſel in a reverberating furnace, covered with its dome; apply a receiver, which need not be luted on for ſome time; and heat the veſſels very ſlowly. At firſt an inſipid water will riſe, which muſt be thrown away: afterwards the Spirit of Salt will appear in white clouds. Now lute your veſſels, and raiſe the fire by degrees; which, towards the end muſt be puſhed to the utmoſt extremity. The operation is known to be finiſhed when no drops fall from the noſe of the retort, the receiver cools, and the white vapours that filled it are ſeen no more.

The Spirit of Salt obtained by the proceſs here delivered does not ſmoke, and contains much more phlegm than that which is diſtilled by means of the concentrated Oil of Vitriol; becauſe the earth, though dried in the ſun, ſtill retains a great deal of moiſture, which commixes with the Acid of the Sea-ſalt. Conſequently it is much eaſier to collect its vapours; ſo that this operation is attended with much leſs trouble than the other. Nevertheleſs it is adviſeable to proceed gently; to apply but little heat at firſt, and to unſtop every now and then the ſmall hole of the receiver: for a quantity of the vapours of Spirit of Salt, even when weakened by the admixture of water, is very apt to burſt the veſſels.

A much greater degree of fire is neceſſary to raiſe the Spirit of Salt by this latter proceſs, than by that in which the pure Vitriolic Acid is employed: for, as faſt as the Spirit of Salt is diſlodged from its own baſis, by the Vitriolic Acid contained in the earth made uſe of, part of it joins that earth, and cannot be ſeparated from it without the moſt violent heat.

A Spirit of Salt that ſhall not ſmoke may alſo be obtained by means of the pure Vitriolic Acid. Spirit of Vitriol, or Oil of Vitriol, lowered with a good deal of water, will do the buſineſs.

Some Chymiſts direct a little water to be placed in the receiver, when Spirit of Salt is to be diſtilled by the intermedium of concentrated Oil of Vitriol, in order to make the acid vapours condenſe more readily. By this means indeed ſome of the inconveniencies attending the diſtillation of ſmoking Spirit of Salt may be avoided: but, on the other hand, the acid vapours being abſolutely ſuffocated by the water as faſt as they come over, the Spirit of Salt obtained by this method will be no leſs aqueous than that procured by the interpoſition of earths: ſo that here is an expence to no manner of purpoſe. Therefore, when a Spirit of Salt is deſired that ſhall not ſmoke, it is beſt to employ an additament of earth; and that ſo much the rather as the Marine Acid obtained by this means is purer and freer from any Vitriolic taint, for the reaſons already aſſigned.

Part of the Acid of Sea-ſalt may be ſeparated from its Alkaline baſis by the force of fire alone, without the intervention of any other body. With this view the Salt muſt be put into the retort without being dried. At firſt an inſipid water riſes; but it gradually becomes acid, and hath all the properties of Spirit of Salt. When the Salt in the retort is grown perfectly dry, nothing more can be forced over by any degree of heat whatever. If you would obtain more Acid from the ſame Salt, you muſt take it out of the retort, where you will find it in a lump, reduce it to powder, and expoſe it to the air for ſome time, that it may attract the moiſture thereof; or elſe wet it at once with ſome rain water, and diſtil as before. You will again have an inſipid water, and a little Spirit of Salt; which will in like manner ceaſe to riſe when the Salt in the retort becomes dry. This operation may be repeated as often as ſhall be thought proper: and perhaps it may be poſſible to decompoſe Sea-ſalt entirely by means thereof, without the interpoſition of any other body. The Spirit of Salt thus obtained is exceeding weak, in ſmall quantity, and loaded with much water.

This experiment proves, that moiſture greatly facilitates the ſeparation of the Acid of Sea-ſalt from the matters with which it is united: and this is the reaſon that, in diſtilling Spirit of Salt with the additament of an earth, the operation requires much leſs fire at the beginning, while the earth and ſalt retain a great deal of humidity, than towards the end, when they begin to grow dry.

After the operation there remains in the retort a ſaline and earthy maſs, which contains, 1. Some entire Sea-ſalt that has ſuffered no decompoſition; 2. A Glauber's Salt which is, as we ſaid before, a Neutral Salt conſiſting of the Vitriolic Acid united with the Alkaline baſis of the Sea-ſalt, from which it hath expelled its proper Acid; 3. Part of the earth uſed as an intermedium, ſtill retaining a portion of its original Vitriolic Acid, which happening not to lie near enough to any particles of Sea-ſalt, could not exert its power in decompoſing them, and ſo remains united with its earthy baſis; 4. Another part of the ſame earth, impregnated with ſome of the Marine Acid, which combined therewith upon being expelled from its Alkaline baſis by the Vitriolic Acid, and which the force of fire was unable to ſeparate from it when the matters were grown perfectly dry. In conſequence of what remains in this *caput mortuum*, if the whole maſs be triturated, moiſtened with a little water, and diſtilled a ſecond time, conſiderably more Spirit of Salt will be obtained from it: and the ſame is to be ſaid of all diſtillations of this ſort.

Spirit of Salt obtained by the means of any other additament than concentrated Oil of Vitriol is generally very weak: but it may be dephlegmated and concentrated, if required, much in the ſame manner as Oil of Vitriol. For this purpoſe you muſt put it into a glaſs cucurbit, ſet it in a *balneum mariæ*, fit thereto a head and a receiver, and with a moderate degree of heat draw off one third or one half of the liquor. What comes over into the receiver will be the moſt aqueous part, which being the lighteſt will riſe firſt, impregnated however with a little acid: in the cucurbit will be left a concentrated Spirit of Salt, or the moſt acid part, which being the heavieſt will not riſe with the degree of heat that is capable of carrying up the phlegm. Spirit of Salt thus concentrated, called alſo *Oil of Salt*, does not ſmoke: it is of a yellow colour inclining to green, and an agreeable ſmell, not unlike that of ſaffron.

PROCESS IV.

To decompoſe Sea-ſalt by means of the Nitrous Acid. Aqua regis. *Quadrangular Nitre.*

TAKE dried Sea-ſalt; bruiſe it to powder; put it into a glaſs retort, leaving one half of the veſſel empty. Pour upon it a third of its weight of good Spirit of Nitre. Place your retort in the ſand-bath of a reverberating furnace; put on the dome; lute to the retort a receiver having a ſmall hole in it, and heat the veſſels very ſlowly. There will come over into the receiver ſome vapours, and an acid liquor. Increaſe the fire gradually till nothing more riſes. Then unlute the veſſels, and pour the liquor out of the receiver into a cryſtal bottle, ſtopped like others containing Acid Spirits.

OBSERVATIONS.

The Nitrous Acid hath a greater affinity than the Marine Acid with fixed Alkalis. When therefore Spirit of Nitre and Sea-ſalt are mixed together, the ſame conſequences, in ſome meaſure, will follow, as when the Vitriolic Acid is mixed with that ſalt; that is, the Nitrous Acid will, like the Vitriolic, decompoſe it, by diſlodging its Acid from its Alkaline baſis, and aſſuming its place. But as the Nitrous Acid is conſiderably weaker, and much lighter, than the Vitriolic Acid, a good deal of it riſes along with the Acid of Sea-ſalt during the operation. The liquor found in the receiver is therefore a true *Aqua regis.*

If decrepitated Salt, and a right ſmoking Spirit of Nitre, be employed in this proceſs, the *Aqua regis* obtained will be very ſtrong; and, during the operation, very elaſtic vapours will ruſh out and burſt the veſſels, if thoſe precautions be not taken which we pointed out as neceſſary in diſtilling the Spirit of Nitre, and the ſmoking Spirit of Salt.

The operation being finiſhed, there is left in the retort a ſaline maſs, containing Sea-ſalt not decompoſed, and a new ſpecies of Nitre, which having for its baſis the Alkali of Sea-ſalt, that is, as we have ſeveral times obſerved, an Alkali of a peculiar nature, differs from the common Nitre, 1. In the figure of its cryſtals; which are ſolids of four ſides, formed like lozenges: 2. In that it cryſtallizes with more difficulty, retains more water in its cryſtals, attracts the moiſture of the air, and diſſolves in water with the ſame circumſtances as Sea-ſalt.

CHAP. IV.

Of BORAX.

PROCESS.

To decompoſe Borax by the means of Acids, and to ſeparate from it the Sedative Salt by ſublimation and by cryſtallization.

REDUCE to a fine powder the Borax from which you intend to extract the Sedative Salt. Put this powder into a wide-necked glaſs retort. Pour upon it an eighth part of its weight of common water, to moiſten the powder; and then add concentrated Oil of Vitriol to the weight of ſomewhat more than a fourth part of the weight of Borax. Set the retort in a reverberatory, make a moderate fire at firſt, and augment it gradually till the retort become red-hot.

A little phlegm will firſt come over, and then with the laſt moiſture that the heat expels the Sedative Salt will riſe; by which means ſome of it will be diſſolved in this laſt phlegm, and paſs therewith into the receiver; but moſt of it will adhere in the form of ſaline flowers to the fore-part of the neck of the retort, juſt where it is clear of the groove of the furnace. There they collect into a heap, which the ſucceeding flowers puſh inſenſibly forward till they ſlightly ſtop the paſſage. Thoſe which riſe after the neck is thus ſtopped ſtick to the after-part of it which is hot, vitrify in ſome meaſure, and form a circle of fuſed Salt. In this ſtate the flowers of the Sedative Salt ſeem to iſſue out of the circle, as from their baſis: they appear like very thin, light, ſhining ſcales, and muſt be bruſhed off with a feather.

At the bottom of the retort will be left a ſaline maſs: diſſolve this in a ſufficient quantity of hot water; filter the ſolution in order to free it from a brown earth which it depoſites; ſet the liquor to evaporate, and cryſtals of Sedative Salt will form in it.

OBSERVATIONS.

Though Borax is of great uſe in many chymical operations, eſpecially in the fuſion of metals, as we ſhall have occaſion to ſee, yet, till of late years, Chymiſts were quite ignorant of its nature, as they ſtill are of its origin; concerning which we know nothing with certainty, but that it comes rough from the Eaſt Indies, and is purified by the Dutch.

M. Homberg was one of the firſt that attempted to analyſe this Salt. He ſhewed, that on mixing it with the Vitriolic Acid, and diſtilling the mixture, a ſalt ſublimes in little fine needles. This product of Borax he called by the name of *Sedative Salt*, becauſe he found it had the propery of moderating the great tumult and heat of the blood in fevers.

After M. Homberg other Chymiſts alſo exerciſed themſelves on Borax. M. Lemery diſcovered, that the Vitriolic is not the only Acid by means of which the Sedative Salt may be obtained from Borax; but that either of the other two Mineral Acids, the Nitrous or the Marine, may be uſed in its ſtead.

M. Geoffroy hath greatly facilitated the means of obtaining the Sedative Salt from Borax; having ſhewn that it may be extracted by cryſtallization as well as by ſublimation; and that the Sedative Salt ſo obtained is in no reſpect inferior to that which was procured before by ſublimation only. To him alſo we are indebted for the diſcovery, that in the compoſition of Borax there is an Alkaline Salt of the ſame nature as the baſis of Sea-ſalt. This he found by obſerving that he got a Glauber's Salt from a ſolution of Borax into which he had poured ſome Vitriolic Acid with a view to obtain its Sedative Salt.

Laſtly, M. Baron, whom we mentioned before on occaſion of this Salt, hath proved, by a great number of experiments, that a Sedative Salt may be procured from Borax by the help of Vegetable Acids, which was never done by any body before him; that the Sedative Salt is not a combination of an Alkaline matter with the Acid made uſe of in extracting it, as ſome of its properties ſeemed to indicate; but that it exiſts previouſly and completely formed in the Borax; that the Acid employed to extract it only helps to diſengage it from the Alkali with which it is united; that this Alkali is actually of the ſame nature as the baſis of Sea-ſalt, becauſe that after extracting the Sedative Salt, which by its union therewith forms the Borax, a Neutral Salt is found, of the ſame ſort with that which would be produced by combining the baſis of Sea-ſalt with the particular Acid made uſe of; that is, if with the Vitriolic Acid, a Glauber's Salt; if with the Nitrous Acid, a quadrangular Nitre; and if with the Marine Acid, a true Sea-ſalt; and, laſtly, that the Sedative Salt may be re-united to its Alkali, and re-produce a Borax.

Nothing therefore now remains, to give us all the inſight we can deſire into the nature of Borax, but to know what the Sedative Salt is. M. Baron hath already given us certain negative notices concerning it, by ſhewing what it is not; that is, that the Acid employed in its extraction doth not enter into its compoſition. We have great reaſon to hope, that he will carry his inquiries ſtill further, and clear up all our doubts on this ſubject.

The Sedative Salt may be extracted from Borax, not only by the means of pure and ſimple Acids, but alſo by the ſame Acids combined with a metallic baſis. Thus Vitriols, for inſtance, may be employed for this purpoſe with good ſucceſs. It is eaſy to ſee, that the Vitriol muſt be decompoſed on this occaſion, and that its Acid cannot unite with the Alkali in which the Sedative Salt is lodged, without quitting its metallic baſis, which muſt of courſe precipitate.

The Sedative Salt actually ſublimes, when a liquid containing it is diſtilled; but it does not therefore follow, that it is naturally volatile. It riſes only by the aid of the water with which it is mixed. The proof of this aſſertion is, that, when all the humidity of the mixture containing this Salt is diſſipated, no more Salt will riſe, be the fire ever ſo violent; and that by adding more water to moiſten the dried maſs containing it, more Salt will every time be obtained, through many repeated diſtillations. In the ſame manner, if ſome Sedative Salt be moiſtened, and expoſed to a proper degree of heat, a ſmall quantity thereof will riſe at firſt by the help of the water; but as ſoon as it grows dry it remains exceedingly fixed. This obſervation we owe to M. Rouelle.

The Sedative Salt hath the appearance and the taſte of a Neutral Salt: it does not change the colour of the juice of violets; nor does it eaſily diſſolve in water; for it requires a quart of boiling water to diſſolve two ounces of it: yet, with regard to Alkalis, it has the properties of an Acid; it unites with thoſe ſalts, forms therewith a ſaline compound which cryſtallizes, and even expels the Acids that happen to be combined with them; ſo that it decompoſes the ſame Neutral Salts that are decompoſed by the Vitriolic Acid.

The Sedative Salt, when ſuddenly expoſed to the violent heat of a naked fire, loſes near half its weight, melts, puts on and retains the appearance of glaſs; but its nature ſtill remains unchanged. This glaſs diſſolves in water, and ſhoots anew into cryſtals of Sedative Salt. This Salt communicates to the Alkaline ſalt with which it is united, when in the form of Borax, the property of melting with a moderate heat, and forming a kind of glaſs; and it is this great fuſibility that recommends the frequent uſe of Borax as a flux for aſſaying ores. It is alſo employed ſometimes as an ingredient in the compoſition of glaſs; but, in time, it always communicates thereto the fault which its own glaſs hath, namely that of tarniſhing with the air. The Sedative Salt hath, moreover, the ſingular property of diſſolving in Spirit of Wine, and of giving to its flame, when ſet on fire, a beautiful green colour. All theſe obſervations we owe to Meſſ. Geoffroy and Baron.

M. Geoffroy prepares the Sedative Salt by cryſtallization only, in the following manner. "He diſſolves four ounces "of refined Borax in a ſufficient quantity of warm water, "and then pours into the ſolution one ounce and two drams "of highly concentrated Oil of Vitriol, which makes a "crackling noiſe as it falls in. When this mixture has "ſtood evaporating for ſome time, the Sedative Salt be"gins to make its appearance in little, fine, ſhining plates "floating on the ſurface of the liquor. The evaporation is "then to be ſtopped, and the plates will by little and little "increaſe in thickneſs and breadth. They unite together "into little tufts, forming with each other ſundry different "groups. If the veſſel be ever ſo little ſtirred, the regulari"ty of the cryſtals will be diſturbed; ſo that it muſt not be "touched till the cryſtallization appears to be finiſhed. The "cryſtalline cluſters, being grown too bulky and too heavy, "will then fall of themſelves to the bottom of the veſſel. "This being obſerved, the ſaline liquor muſt be gently de"canted from thoſe little cryſtals, which, as they are not "eaſily diſſolved, muſt be waſhed clean, by pouring cold "water ſlowly on the ſides of the pan, three or four times "ſucceſſively, in order to rinſe out all remains of the ſaline "liquor, and then ſet firſt to drain, and afterwards to dry "in the ſun. This Salt, in the form of light flakes of "ſnow, is now ſoft to the touch, cool in the mouth, ſlight"ly bitter, crackling a little between the teeth, and leaving "a ſmall impreſſion of acidity on the tongue. It will keep "long without giving or calcining, if managed according

" to the preceding directions; that is, if it be exactly freed
" from its ſaline liquor.

" It differs from the Sedative Salt obtained by ſublima-
" tion in this reſpect only, that notwithſtanding its ſeeming
" lightneſs it is a little heavier than the other. M. Geoffroy
" ſuppoſes the cauſe of this weight to be, that, as ſeveral of
" the thin plates adhere together in cryſtallizing, they retain
" between them ſome ſmall matter of humidity; or, if you
" will, that, as they form larger cryſtals, they preſent leſs
" ſurface to the air which elevates light bodies: whereas, on
" the contrary, the other Sedative Salt, being driven up by
" the force of fire, riſes into the head of the cucurbit in a
" more ſubtile form, having its particles much more expanded
" and divided.

" M. Geoffroy, having put his Sedative Salt made by
" cryſtallization to all the ſame trials with that made by ſub-
" limation, ſatisfied himſelf that there is no other difference
" between the two. If the Sedative Salt made by cryſtalli-
" zations happens to calcine in the ſun; that is, if its luſtre
" tarniſhes, and its ſurface grows mealy, it is a ſign that it
" ſtill contains either a little Borax or ſome Glauber's Salt:
" for theſe two Salts are apt to calcine in this manner, and
" pure Sedative Salt ſhould not be ſubject to this inconve-
" nience. In order to purify it, and free it entirely from
" thoſe Salts, it muſt be diſſolved once more in boiling wa-
" ter. As ſoon as the water cools, the Sedative Salt re-
" appears in light, ſhining, cryſtalline plates, ſwimming in
" the liquor. After ſtanding four and twenty hours, the li-
" quor muſt be decanted, and the ſalt waſhed with freſh
" water; by which means it will be very pure and beau-
" tiful."

Glauber's Salt and Borax diſſolve in water with vaſtly more eaſe than the Sedative Salt, and conſequently do not cryſtallize ſo readily by much: ſo that the ſmall portion of thoſe ſalts which may have been left on the ſurface of the Sedative Salt, being diffuſed through a large quantity of water, continues in a ſtate of ſolution, while the Sedative Salt cryſtallizes; which being alſo waſhed afterwards with fair water, it is impoſſible that the ſmalleſt particle of thoſe other Salts ſhould remain adhering to it; and conſequently this muſt be deemed an excellent way of purifying it.

SECTION II.

Of Operations on METALS.

CHAP. I.

Of GOLD.

PROCESS I.

To ſeparate Gold, by Amalgamation with Mercury, from the Earth and Stones with which it is found mixed.

PULVERIZE the earths and ſtones containing Gold. Put the powder into a little wooden tray; dip this tray in water, gently ſhaking it and its contents. The water will grow muddy, by taking up the earthy parts of the ore. Continue waſhing it in this manner till the water ceaſe to appear turbid. Upon the ore thus waſhed pour ſtrong vinegar, having firſt diſſolved therein, by the help of heat, about a tenth part of its weight of alum. The powder muſt be quite drenched and covered with this liquor, and ſo left to ſtand for twice twenty-four hours.

Decant the vinegar, and waſh your powder with warm water, till the laſt that comes off hath no taſte: then dry it, and put it into an iron mortar, with four times its weight of Quick-ſilver: triturate the whole with a heavy wooden peſtle, till all the powder be of a blackiſh colour: then pour in a little water, and continue rubbing for ſome time longer. More earthy and heterogeneous particles will be ſeparated from the metalline parts by means of this water, which will look dirty: it muſt then be decanted, and more fair water added. Repeat this ſeveral times; then dry what remains in the mortar with a ſponge, and by the help of a gentle heat: you will find it an Amalgam of the Mercury with the Gold.

Put this Amalgam into a chamoy bag: tie a knot on its neck, and ſqueeze it hard between your fingers, over ſome wide-mouthed veſſel; there will iſſue through the pores of the leather numberleſs little jets of Mercury, forming a ſort of ſhower, that will collect into large globules in the veſſel placed underneath. When you can force out no more Mercury by this means, open the bag, and in it you will find the Amalgam freed from the ſuperfluous Mercury; the Gold retaining only about as much thereof as nearly equals itſelf in weight.

Put this Amalgam into a glaſs retort; ſet this retort in the ſand-bath of a reverberating furnace; cover it quite over with ſand; apply a glaſs receiver half full of water, ſo that the noſe of the retort may be under the water. The receiver need not be luted to the retort. Give a gradual heat, and raiſe the fire till drops of the ſublimed Mercury appear in the neck of the retort, and fall into the water with a hiſſing noiſe. If you hear any noiſe in the retort ſlacken your fire a little. Laſtly, when you obſerve, that, though you raiſe the fire ſtill higher than before, nothing more will come over, take out your retort, break it, and there you will find the Gold, which muſt be melted in a crucible with Borax.

OBSERVATIONS.

GOLD is a perfect metal, which can by no means be deprived of its Phlogiſton, and on which few, even of the moſt powerful chymical ſolvents, have any effect: and therefore it almoſt always hath its metalline form when found in the earth; from which it may ſometimes be ſeparated by ſimple lotion. The Gold duſt found in the ſands of certain rivers is of this kind. When it reſides in ſtones, or tenacious earths, it may be extracted by the proceſs here delivered; to wit, by Amalgamation, or combination of Mercury with Gold. Mercury is incapable of uniting with any earthy ſubſtances, not even with the metallic earths, when they are deprived of their Phlogiſton, and conſequently have not the metalline form.

Hence it follows, that when Mercury is triturated with particles of Gold, of earth, and of ſtone, mingled together, it unites with the Gold, and ſeparates it from thoſe heterogeneous matters. Yet, if there be along with the Gold any other metal, in its metalline form, except Iron, the Mercury will amalgamate with that alſo. This often happens to Silver, which being a perfect metal as well as Gold, is for that reaſon ſometimes dug up in its metalline form, and even incorporated with Gold. When this is the caſe, the maſs that remains in the retort, after abſtracting the Mercury of the Amalgama, is a compound of Gold and Silver, which are to be ſeparated from each other by the methods we ſhall give for that purpoſe. The preſent proceſs is therefore applicable to Silver as well as Gold.

Sometimes Gold is intimately combined with ſuch mineral matters as hinder the Mercury from acting upon it. In that caſe the mixed maſs muſt be roaſted before you proceed to Amalgamation: for if the matters be volatile, ſuch, for inſtance, as antimony or arſenic, the fire will carry them off; ſo that, after roaſting, the Amalgamation will ſucceed. But ſometimes theſe matters are fixed, and require fuſion; if ſo, recourſe muſt be had to ſome particular methods, which we ſhall deſcribe when we come to treat of Silver, as theſe two perfect metals are to be treated in the ſame manner.

Ores containing Gold muſt be waſhed before an Amalgam is attempted; that the metalline parts, being freed from the numerous particles of earth with which they are encompaſſed, may the more readily incorporate with the Mercury. Beſides, it is the property of Mercury to take the form of a dark unmetallic powder, after being long rubbed with other matters, ſo that it cannot be eaſily diſtinguiſhed from the particles of earth. And hence, if you ſtill continue to grind the matters together, after the Amalgamation is completed, and waſh them again and again, the water that comes off will always look turbid, being impregnated with ſome particles of the Amalgam. This is eaſily proved: for if you let the turbid water ſettle, and diſtil the ſediment, you will obtain Quickſilver from it.

The ore is to be ſteeped in vinegar charged with alum, in order to cleanſe the ſurface of the Gold, which is often covered with a thin coat of earth that obſtructs the Amalgamation.

Great care muſt be taken that the Mercury employed in this operation be very pure. If it be adulterated with any metallic ſubſtance, it muſt be freed therefrom by the methods which we ſhall propoſe in their proper place.

The way of ſeparating Mercury from Gold is founded on the different properties of theſe two metallic ſubſtances; the one being exceedingly fixed, and the other very volatile. The union which Mercury contracts with the metals is not intimate enough, to give the new compound which reſults therefrom all the properties of either of the two united ſubſtances; at leaſt ſo far as concerns their degrees of fixity and volatility. Hence it comes, that, in our Amalgam, the Gold

commu-

communicates but very little of its fixity to the Mercury, and the Mercury communicates to the Gold but very little of its volatility. Yet if the Mercury be diſtilled off with a much greater degree of heat than is neceſſary to elevate it, a pretty conſiderable quantity of Gold will moſt certainly be carried up along with it.

It is alſo of conſequence, on another account, that the fire be duly governed on this occaſion. For if too great a degree of heat be applied, and the fire afterwards lowered, the water in the receiver, which covers the noſe of the retort, will riſe into its body, break it to pieces, and ſpoil the operation.

The cauſe of this phenomenon depends on the property which air poſſeſſes of rarefying with heat and condenſing with cold, joined to its weight. As ſoon as the retort is acted on by a leſs degree of heat than acted on it the inſtant before, the air contained therein is condenſed, and leaves a *vacuum*, which the external air, by virtue of its weight, tends to occupy; but, the orifice of the retort being under water, the external air can no way gain admittance, but by puſhing in before it the water which intercepts its paſſage. This caution, as we obſerved above, muſt be applied to all diſtillations, where the veſſels are diſpoſed as they are in this.

Care muſt alſo be taken that the noſe of the retort be not placed too deep under water: for as the neck grows very warm during the operation, becauſe the degree of heat required to raiſe Mercury is about three times greater than that which raiſes water, it may eaſily be broken by the contact of the cold water in the receiver.

This method of extracting Gold and Silver from their ores, by Amalgamation with Mercury, is not to be abſolutely depended on as a ſure proof of the quantity of thoſe metals that may be contained in the earth aſſayed by this means: for ſome ſmall part of the Amalgam is always loſt in waſhing it; and, moreover, the Mercury, when ſqueezed through chamoy, always carries with it a ſmall portion of Gold. So that if you deſire to know more exactly, by this method, the quantity of Gold or Silver contained in any earth, the Amalgam muſt not be ſqueezed through chamoy, but diſtilled altogether. Much the ſureſt method of making an accurate aſſay is that by fuſion and ſcorification, which we ſhall deſcribe under the head of Silver.

In ſome countries, and eſpecially in America, the method of Amalgamation is uſed for extracting Gold and Silver in large quantities, from the matrices which contain them in their metalline form. Agricola and other metallurgiſts have deſcribed the machines by means whereof ſuch Amalgamations are managed.

PROCESS II.

To diſſolve Gold in Aqua regis, *and by that means to ſeparate it from Silver.* Aurum Fulminans. Aurum Fulminans *reduced.*

TAKE Gold that is perfectly pure, or alloyed with Silver only. Reduce it to little thin plates, by hammering it on an anvil. If it be not ſufficiently tough, neal it till it be red in a moderate, clear fire, quite free from ſmoking coals, and then let it cool gradually, which will reſtore its ductility.

When the plates are thin enough, make them red hot once more, and cut them into ſmall bits with a pair of ſheers. Put theſe bits into a tall, narrow-mouthed cucurbit, and pour on them twice their weight of good *Aqua regis*, made of one part Sal Ammoniac, or Spirit of Salt, and four parts Spirit of Nitre. Set the cucurbit in a ſand-bath moderately heated, ſtopping its orifice ſlightly with a paper coffin, to prevent any dirt from falling in. The *Aqua regis* will preſently begin to ſmoke. Round the little bits of Gold will be formed an infinite number of ſmall bubbles, which will riſe to the ſurface of the liquor. The Gold will totally diſſolve, if it be pure, and the ſolution will be of a beautiful yellow colour: if the Gold be alloyed with a ſmall quantity of Silver, the latter will remain at the bottom of the veſſel in the form of a white powder. If the Gold be alloyed with much Silver, when the Gold is diſſolved the Silver will retain the form of the little metalline plates put into the veſſel.

When the diſſolution is completed, gently pour off the liquor into another low, wide-mouthed, glaſs cucurbit, taking care that none of the Silver, which lies at the bottom in the form of a powder, eſcape with the liquor. On this powder of Silver pour as much freſh *Aqua regis* as will cover it entirely; and repeat this till you are ſure that nothing more can be taken up by it. Laſtly, having decanted the *Aqua regis* from the Silver, waſh the Silver with a little Spirit of Salt weakened with water, and add this Spirit of Salt to the

Aqua regis in which your Gold is diſſolved. Then to the body containing theſe liquors fit a head and a receiver, and diſtil with a gentle heat, till the matter contained in the cucurbit become dry.

OBSERVATIONS.

It is certain that *aqua regis* is the true ſolvent of Gold, and that it does not touch Silver: ſo that if the Gold diſſolved in it were alloyed with Silver, which is often the caſe, the two metals would by this means be pretty accurately ſeparated from each other. But if you deſire to obtain from this ſolution a Gold abſolutely pure, you muſt free it, before you diſſolve it, from every other metallic ſubſtance but Silver; becauſe *aqua regis* acts upon moſt of the other metals and the ſemi-metals. We ſhall ſhew under the head of Silver, as we promiſed before, how to purify a maſs of Gold and Silver from every other metallic alloy. Thither alſo we refer the common parting aſſay performed by means of *aqua fortis*: becauſe in that operation the Silver is diſſolved, and not the Gold.

If the Gold put to diſſolve in *aqua regis* be pure, the diſſolution is eaſily and readily effected. But if, on the contrary, it be alloyed with Silver, the *aqua regis* finds more difficulty in diſſolving it. Nay, if the Silver exceed the Gold in quantity, the diſſolution will not take place at all, for the reaſons adduced in our Theoretical Elements; of which we ſhall ſpeak more fully when we come to treat of the Parting Aſſay.

In the proceſs we directed the Gold to be diſſolved in a tall body. This precaution is neceſſary to prevent the loſs of ſome part thereof: for it is the property of *aqua regis* to carry off along with it ſome of the Gold, eſpecially when there is any Sal Ammoniac in its compoſition, if the veſſel be heated while the diſſolution is going on, or if the *aqua regis* be very ſtrong. Yet it is proper to make uſe of *aqua regis* that is too ſtrong rather than too weak: for if it prove too ſtrong, and be obſerved not to act upon the metal for that reaſon, it is eaſy to weaken it, by gradually adding ſmall quantities of pure water, till you perceive it begin to act with vigour. This is a general rule regarding all metallic diſſolutions in Acids.

When the ſolution of Gold is evaporated to dryneſs, if you deſire to reduce into a maſs the Gold duſt left at the bottom of the cucurbit, you muſt put it into a crucible, and cover it with pulverized borax, mixed with a little nitre and calcined wine-lees; then cover the crucible cloſe, heat it with a moderate fire, which muſt be afterwards increaſed ſo as to melt the contents. At the bottom of the crucible you will find a lump of Gold, over which the ſalts you added will be as it were vitrified. Theſe ſalts are added chiefly to promote the fuſion of the metal.

The Gold may, if you will, be ſeparated from its ſolvent without evaporating the ſolution as above directed. You need only mix with the ſolution a fixed or volatile Alkali by little and little, till you ſee no more precipitate fall, and then let the liquor ſtand to ſettle, at the bottom of which you will find a ſediment: filter the whole, and dry what is left on the filter.

Both fixed and volatile Alkalis poſſeſſing, as hath been frequently repeated, a greater affinity with Acids than metallic ſubſtances have, they precipitate the Gold, and ſeparate it from the Acids in which it is diſſolved: but it is of great conſequence to take notice, that, if you attempt to melt this precipitated Gold in a crucible, it will fulminate as ſoon as it feels the heat, with ſuch a terrible exploſion, that, if the quantity be at all conſiderable, it may prove fatal to the operator: even rubbing it a little hard will make it blow up. This preparation is therefore called *Aurum Fulminans*.

Hitherto no ſatisfactory explanation hath been given of this phenomenon. Some Chymiſts conſidering, that, in the precipitation of the Gold, a Nitre is regenerated by the union of the Alkali with the Nitrous Acid which enters into the compoſition of the *aqua regis*, imagine that ſome of this regenerated Nitre, combining with the precipitated Gold, takes fire and detonates, either by means of ſome ſmall portion of Phlogiſton that may be contained in the Alkali, or by means of that which conſtitutes the Gold itſelf. But, in the firſt place, it is well known that Fixed Alkalis do not contain Phlogiſton enough to make Nitre detonate. Indeed, if a Volatile Alkali be employed in the precipitation, a Nitrous Ammoniacal Salt will be formed, containing Phlogiſton enough to be capable of detonating without the concourſe of any additional Phlogiſton: but this detonation of the Nitrous Ammoniacal Salt is not to be compared, as to the violence of its effects, with the fulmination of Gold. Beſides, we do not find that Gold precipitated by a Volatile Alkali explodes with greater force than that precipitated by a Fixed Alkali. As for the Gold, it is certain that it ſuffers no decompoſition at all by fulminating. When fulminated under a glaſs bell, in ſuch ſmall quantities as not to endanger the operator, the Gold is found ſcattered about under the bell in very fine particles, without having undergone any alteration.

Others have fancied this fulmination of the Gold to be nothing but the decrepitation of the Sea-ſalt that is regenerated, in the precipitation of the metal, by the Fixed Alkali uniting with the Acid of Sea-ſalt which makes part of the *aqua regis*. But to this it may be ſaid, that Gold precipitated by a Volatile Alkali fulminates as violently as that precipitated by a Fixed Alkali; and yet no ſea-ſalt can be formed in the liquor by the addition of a Volatile Alkali, but only a Sal Ammoniac which has not the property of decrepitating. Moreover, there is no compariſon, as to the effects, between the decrepitation of Sea-ſalt and the fulmination of Gold.

Nor, laſtly, can this fulmination be attributed, as it is by ſome, to the effort made by the Salts to eſcape from amidſt the particles of Gold, in which they are ſuppoſed by them to be impriſoned: for then we might deprive this Gold entirely of its fulminating quality by only boiling it in water, and ſo waſhing off all the ſaline particles, which probably adhere to its ſurface only. It is plain there is great room for very beautiful diſcoveries on this ſubject. In Walerius's Mineralogy we find ſome obſervations that may throw a little light on the point before us.

"The quantity," ſays he, "of fulminating Gold precipitated exceeds that of the Gold diſſolved: if the *aqua regis* be made with Sal Ammoniac the exploſion will be ſtronger; it will alſo be more violent if the ſolution be precipitated with a Volatile Alkali, than if a Fixed Alkali be uſed for that purpoſe."

One of the ſpeedieſt and eaſieſt methods to deprive this Gold of its fulminating quality, is to grind in a mortar twice as much flowers of Sulphur as you have Gold to reduce, mixing your fulminating Gold therewith by little and little, as you grind them together; then to put the mixture into a crucible, and heat it juſt enough to melt the Sulphur. Part of the Sulphur will be diſſipated in vapours, and the reſt will burn away. When it is quite conſumed, increaſe the fire ſo as to make the crucible red-hot. When you perceive no more ſmell of Sulphur, pour on the Gold a little Borax, previouſly melted in another crucible with a Fixed Alkali, as calcined Wine-lees, or Nitre fixed with Tartar; and then raiſe the fire ſufficiently to make the whole flow. After the fuſion is completed, you will find a button of Gold at the bottom of the crucible under the Salts.

Fulminating Gold may alſo be reduced by pouring on it a ſufficient quantity of Fixed Alkali reduced to a liquor, or of oil of Vitriol, evaporating all the moiſture, and gradually throwing what remains, mixed up with ſome pinguinous matter, into a crucible kept red-hot in a furnace. The reaſon why theſe ſubſtances deprive the Gold of its fulminating quality, depends on the cauſes that produce the fulmination.

Gold may alſo be ſeparated from *aqua regis*, and precipitated by the means of ſeveral metallic ſubſtances that have a greater affinity, either with *aqua regis*, or with one of the two Acids that compoſe it. Mercury is one of the fitteſt for this purpoſe. On dropping a ſolution of Mercury in the Nitrous Acid by little and little into a ſolution of Gold, the mixture becomes turbid, and a precipitate is formed. Continue dropping in more of the ſolution of Mercury till no more precipitate falls; then let the liquor ſtand to ſettle, and at the bottom of it you will find a ſediment, which is the precipitated Gold: pour off the liquor by inclination, and waſh the precipitate with fair water.

Mercury hath a greater affinity with the Marine than with the Nitrous Acid. The affinity which Mercury hath with the Marine Acid is alſo greater than that of Gold with the Marine Acid; for unleſs this Acid be aſſociated either with the Nitrous Acid, or at leaſt with a certain proportion of Phlogiſton, it will not diſſolve Gold. Hence it comes, that when a ſolution of Mercury in the Nitrous Acid is dropped into a ſolution of Gold in *aqua regis*, the Mercury unites with the Acid of Sea-ſalt, which is an ingredient in the *aqua regis:* but the Marine Acid cannot on this occaſion join the Mercury, without deſerting the Gold and the Nitrous Acid with which it was united; and then the Gold, which cannot be kept in ſolution by the Nitrous Acid alone, is forced to quit its ſolvent and precipitate. The liquor, therefore, that now floats over the Gold thus precipitated, muſt contain Mercury united with the Acid of Sea-ſalt: and in fact it yields a true Corroſive Sublimate, which is known to be a combination of Mercury with the Marine Acid.

Mercury diſſolved in Spirit of Nitre is employed to procure the precipitation we are ſpeaking of; becauſe metallic ſubſtances, when ſo comminuted by an Acid, are much fitter for ſuch experiments than when they are in a concrete form.

Gold precipitated in this manner by a metallic ſubſtance doth not fulminate.

PROCESS III.

To diſſolve Gold by Liver of Sulphur.

MIX together equal parts of common Brimſtone, and a very ſtrong Fixed Alkali; for inſtance, Nitre fixed by Charcoal. Put them in a crucible, and melt the mixture, ſtirring it from time to time with a ſmall rod. There is no occaſion to make the fire very briſk; becauſe the Sulphur facilitates the fuſion of the Fixed Alkali. Some ſulphureous vapours will riſe from the crucible; the two ſubſtances will mix intimately together, and form a reddiſh compound. Then throw into the crucible ſome little pieces of Gold beat into thin plates, ſo that the whole do not exceed in weight one third part of the Liver of Sulphur: raiſe the fire a little. As ſoon as the Liver of Sulphur is perfectly melted, it will begin to diſſolve the Gold with ebullition; and will even emit ſome flaſhes of fire. In the ſpace of a few minutes the Gold will be entirely diſſolved, eſpecially if it was cut and flatted into ſmall thin leaves.

OBSERVATIONS.

THE proceſs here delivered is taken from M. Stahl. The deſign of that ingenious Chymiſt's inquiry was to diſcover how Moſes could burn the golden calf, which the Iſraelites had ſet up and worſhipped while he was on the mount; how he could afterwards reduce that calf to powder, throw it into the water which the people uſed, and make all who had apoſtatized drink thereof, as related in the Book of Exodus.

M. Stahl, having firſt obſerved that Gold is abſolutely unalterable and indeſtructible by the force of fire alone, be it ever ſo violent, concludes, that without a miracle Moſes could not poſſibly perform the above-mentioned operations on the golden calf any way but by mixing with the Gold ſome matter qualified to alter and diſſolve it. He then takes notice, that pure Sulphur does not act upon Gold at all, and that many other ſubſtances, which are thought capable of dividing and diſſolving it, cannot however do it ſo completely as is neceſſary to render that metal ſuſceptible of the effects related. He then gives the method of diſſolving it by Liver of Sulphur, deſcribed in the proceſs.

Liver of Sulphur diſſolves likewiſe all the other metals: but M. Stahl obſerves, that it attenuates Gold more than any other metallic ſubſtance, and unites with it much more intimately than with the reſt. This appears from what happens, on attempting to diſſolve in water any of the mixts reſulting from the union of another metal with the Liver of Sulphur: for then the metal ſeparates, and appears in the form of a powder or fine calx; whereas, when Gold is united with Liver of Sulphur, the whole compound diſſolves in water ſo perfectly, that the Gold even paſſes with the Liver of Sulphur through the pores of filtering paper.

If an Acid be poured into a ſolution of this combination of Gold with Liver of Sulphur, the Acid unites with the Alkali of the *Hepar*, and the Gold falls to the bottom of the liquor along with the Sulphur, which doth not quit it. The Sulphur thus precipitated with the Gold is eaſily carried off by a ſlight torrefaction, after which the Gold remains exceedingly comminuted. The Sulphur of this compound may alſo be deſtroyed by torrefaction, without the trouble of a previous ſolution and precipitation, and then alſo the Gold remains ſo attenuated as to be miſcible with liquors, and floats on them, or ſwims in them, in ſuch a manner that it may eaſily be ſwallowed with them in drinking. From all this M. Stahl concludes there is great reaſon to believe it was by means of the Liver of Sulphur that Moſes divided, and in a manner calcined, the golden calf, ſo that he could mingle it with water, and make the Iſraelites drink it.

PROCESS IV.

To ſeparate Gold from all other metallic Subſtances by means of Antimony.

HAVING put the Gold you intend to purify into a crucible, ſet it in a melting furnace, cover it, and make the Gold flow. When the metal is in fuſion caſt upon it, by a little at a time, twice its weight of pure crude Antimony in powder, and after each projection cover the crucible again immediately: this done keep the matter in fuſion for a few minutes. When you perceive that the metallic mixture is perfectly melted, and that its ſurface begins to ſparkle, pour it out into a hollow iron cone, previouſly heated, and ſmeared on the inſide with tallow. Immediately ſtrike with a hammer the floor on which the cone ſtands;

and

and when all is cold, or at leaſt ſufficiently fixed, invert the cone and ſtrike it: the whole metallic maſs will fall out, and the under part thereof, which was at the point of the cone, will be a Regulus more or leſs yellow as the Gold was more or leſs pure. On ſtriking the metallic maſs the Regulus will freely part from the ſulphureous cruſt at top.

Return this Regulus into the crucible, and melt it. Leſs fire will do now than was required before. Add the ſame quantity of Antimony, and proceed as at firſt. Repeat the ſame operation a third time, if your Gold be very impure.

Then put your Regulus into a good crucible, much larger than is neceſſary to hold it. Set your crucible in a melting furnace, and heat the matter but juſt enough to make it flow, with a ſmooth, brilliant ſurface. When you find it thus conditioned, point towards it the noſe of a long-ſnouted pair of bellows, and therewith keep gently and conſtantly blowing. There will ariſe from the crucible a conſiderable ſmoke, which will abate greatly when you ceaſe to blow, and increaſe as ſoon as you begin again. You muſt raiſe the fire gradually as you approach towards the end of the operation. If the ſurface of the metal loſe its brilliant poliſh, and ſeem covered with a hard cruſt, it is a ſign the fire is too weak; in which caſe it muſt be increaſed, till the ſurface recover its ſhining appearance. At laſt, when no more ſmoke riſes, and the ſurface of the Gold looks neat and greeniſh, caſt on it, by little and little, ſome pulverized Nitre, or a mixture of Nitre and Borax. The matter will ſwell up. Continue thus adding more Nitre gradually, till no commotion is thereby produced in the crucible; and then let the whole cool. If you find, when the Gold is cold, that it is not tough enough, melt it over again; when it begins to melt, caſt in the ſame Salts as before; and repeat this till it be perfectly ductile.

OBSERVATIONS.

ANTIMONY is a compound, conſiſting of a ſemi-metallic part united with about a fourth part of its weight of common Sulphur. It appears, in the ninth column of the Table of Affinities, that all the metals, Mercury and Gold excepted, have a greater affinity than the reguline part of Antimony with Sulphur. If therefore Gold, adulterated with a mixture of Copper, Silver, or any other metal, be melted with Antimony, thoſe metals will unite with the Sulphur of the Antimony, and ſeparate it from the reguline part, which being thus ſet free will combine and be blended with the Gold. Theſe two metallic ſubſtances, forming a maſs far heavier than the other metals mixed with the ſulphur, fall together to the bottom of the crucible in the form of a Regulus, while the others float over them like a ſort of ſcoria or ſlag: and thus the Gold is freed from all alloy but the reguline part of the Antimony.

As all the other metals have a great affinity with Sulphur, and Gold is the only one that is capable of reſiſting its action, one would think Sulphur alone might be ſufficient to free it from the metals combined with it, and that it would therefore be better to employ pure Sulphur, in this operation, than to make uſe of Antimony; the reguline part of which remaining united with the Gold requires another long and laborious operation to get rid of it.

Indeed, ſtrictly ſpeaking, Sulphur alone would be ſufficient to produce the deſired ſeparation: but it is proper to obſerve, that, as Sulphur alone is very combuſtible, moſt of it would be conſumed in the operation before it could have an opportunity to unite with the metallic ſubſtances; whereas, when it is combined with the Regulus of Antimony, it is thereby enabled to bear the action of the fire much longer without burning, and conſequently is much fitter for the purpoſe in queſtion. Beſides, if we were to make uſe of pure Sulphur, a great part of the Gold, which is kept in perfect fuſion, and its precipitation facilitated, by the Regulus of Antimony, would remain confounded with the Sulphureous ſcoria.

Nevertheleſs, ſeeing the metals with which Gold is alloyed cannot be ſeparated from it by Antimony, but that a quantity of Regulus proportioned to the quantity of the metals ſo ſeparated will unite with the Gold, and that the more Regulus combines with the Gold, the more tedious, chargeable, and laborious will the operation prove, this conſideration ought to have ſome influence in directing our proceſs. Therefore, if the Gold be very impure, and worſe than ſixteen carats, we muſt not mix it with crude Antimony alone, but add two drams of pure Sulphur for every carat the Gold wants of ſixteen, and leſſen the quantity of Antimony in proportion to that of the real Gold.

It is neceſſary to keep the crucible cloſe covered, after mixing the Antimony with the Gold, to prevent any coals from falling into it: for, if that ſhould happen, the melted maſs would puff up conſiderably, and might perhaps run over.

The inſide of the cone, into which you pour the melted metallic maſs, muſt be greaſed with tallow, to prevent its ſticking thereto, and that it may come eaſily out. Striking the floor, on which the cone with the melted metal ſtands, helps the precipitation and deſcent of the Regulus of Gold and Antimony to the bottom of the cone.

Leſs fire is requiſite to melt this compound Regulus, in order to add freſh Antimony, than was neceſſary before the Gold was mixed with the reguline part of the Antimony; becauſe this metallic ſubſtance, being much more fuſible than Gold, promotes its melting. The Antimony is mixed with the Gold by repeated projections, that the ſeparation of the metals may be accompliſhed with the greater eaſe and accuracy. Yet the operation might be ſucceſsfully performed, by putting in all the Antimony at once, and with one melting only.

The metalline maſs found at the bottom of the cone after all theſe operations, is a mixture of Gold with the reguline part of the Antimony. All the reſt of the proceſs conſiſts only in ſeparating this reguline part from the Gold. As Gold is the moſt fixed of all metals, and as the Regulus of Antimony cannot bear the violence of fire without flying off in vapours, nothing more is neceſſary for this purpoſe but to expoſe the compound, as directed in the proceſs, to a heat ſtrong enough and long enough continued, to diſſipate all the Regulus of Antimony. This ſemi-metal exhales in the form of a very thick white ſmoke. It is proper to blow gently into the crucible during the whole operation; becauſe the immediate contact of the freſh air inceſſantly thrown in promotes and conſiderably increaſes the evaporation: and this is a general rule applicable to all evaporations.

The fire muſt be gradually raiſed as the Regulus of Antimony is diſſipated, and the operation draws towards an end; becauſe the mixed maſs of Regulus of Antimony and Gold becomes ſo much the leſs fuſible as the proportion of the Regulus is leſſened. Though the Regulus of Antimony be ſeparated from the Gold in this operation, becauſe the latter is of ſuch a fixed nature that it cannot be volatilized by the degree of fire which diſſipates the Regulus; yet, as the Regulus is very volatile, it will undoubtedly carry up ſome of the Gold along with it, eſpecially if you hurry on the evaporation too faſt, by applying too great a degree of fire, by blowing too briſkly into the crucible, and ſtill more if you evaporate your mixture in a broad flat veſſel inſtead of a crucible. All theſe things muſt therefore be avoided, if you would loſe no more Gold than you needs muſt.

However, unleſs the evaporation be carried to the utmoſt, by the means above pointed out, a ſmall portion of the Regulus of Antimony will always remain combined with the Gold, which defends it from the action of the fire. This ſmall portion of Regulus hinders the Gold from being perfectly pure and ductile. In order therefore to conſume and ſcorify it, we caſt Nitre into the crucible when we perceive it to emit no more white vapours.

We know that Nitre has the property of reducing all metallic ſubſtances to a calx, Gold and Silver excepted; becauſe it deflagrates with the phlogiſton to which their metalline form is owing: but as this accenſion of the Nitre occaſions a tumid effervefcence, care muſt be taken to throw it in but by little and little at a time; for if too much be projected at once the melted matter will run over.

This operation might be conſiderably abridged by taking advantage of the property which Nitre poſſeſſes of thus conſuming the phlogiſton of metallic ſubſtances; as by means thereof we might deſtroy all the Regulus of Antimony incorporated with the Gold, without having recourſe to a long and tedious evaporation. But then we ſhould at the ſame time loſe a much greater quantity of Gold, by reaſon of the tumult and ebullition which are inſeparable from the detonation of Nitre. On the whole, therefore, if Nitre be made uſe of to purify Gold, great care muſt be taken to apply but very little of it at a time.

All the Silver that was mixed with the Gold, and indeed a little of the Gold itſelf, remains confounded with the ſulphureous ſcoria, which floats upon the Golden Regulus after the addition of the Antimony: we ſhall ſhew in the Chapter on Silver how theſe two metals are to be ſeparated from the Sulphur.

CHAP. II.

Of SILVER.

PROCESS I.

To ſeparate Silver from its Ore, by means of Scorification with Lead.

BEAT to powder in an iron mortar the ore from which you mean to ſeparate the Silver, having firſt roaſted it well in order to free it from all the Sulphur and Arſenic that it may contain. Weigh it exactly: then weigh out by itſelf eight times as much granulated Lead. Put one half of this Lead into a teſt, and ſpread it equally thereon: upon this Lead lay your ore, and cover it quite over with the remaining half of the Lead.

Place the teſt thus loaded under the further end of the muffle in a cupelling furnace. Light your fire, and increaſe it by degrees. If you look through one of the apertures in the door of the furnace you will perceive the ore, covered with calcined Lead, ſwim upon the melted Lead. Preſently afterwards it will grow ſoft, melt, and be thrown towards the ſides of the veſſel, the ſurface of the Lead appearing in the midſt thereof bright and ſhining like a luminous diſc: the Lead will then begin to boil, and emit fumes. As ſoon as this happens, the fire muſt be a little checked, ſo that the ebullition of the Lead may almoſt entirely ceaſe, for about a quarter of an hour. After this it muſt be excited to the degree it was at before, ſo that the Lead may begin again to boil and ſmoke. Its ſhining ſurface will gradually leſſen, and be covered with *ſcoriæ*. Stir the whole with an iron hook, and draw in towards the middle what you obſerve towards the ſides of the veſſel; to the end that, if any part of the ore ſhould ſtill remain undiſſolved by the Lead, it may be mixed therewith.

When you perceive that the matter is in perfect fuſion, that the greateſt part of what ſticks to the iron hook, when you dip it in the melted matter, ſeparates from it again, and drops back into the veſſel; and that the extremity of this inſtrument,

ſtrument, when grown cold, appears varniſhed over with a thin, ſmooth, ſhining cruſt; you may look on theſe as marks that the buſineſs is done, and the more uniform and evenly the colour of the cruſt is, the more perfect may you judge the ſcorification to be.

Matters being brought to this paſs, take the teſt with a pair of tongs from under the muffle, and pour its whole contents into an iron cone, firſt heated and greaſed with tallow. This whole operation laſts about three quarters of an hour. When all is cold, the blow of a hammer will part the Regulus from the ſcoria; and as it is not poſſible, how perfect ſoever the ſcorification be, to avoid leaving a little Lead containing Silver in the ſcoria, it is proper to pulverize this ſcoria, and ſeparate therefrom whatever extends under the hammer, in order to add it to the Regulus.

OBSERVATIONS.

SILVER, as well as Gold, is often found quite pure, and under its metalline form, in the bowels of the earth; and in that caſe it may be ſeparated from the ſtones or ſand in which it is lodged by ſimple waſhing, or by Amalgamation with Mercury, in the ſame manner as before directed for Gold. But it alſo happens frequently, that Silver is combined in the ore with other metallic ſubſtances and minerals, which will not admit of this proceſs, but force us to employ other methods of ſeparating it from them.

Sulphur and Arſenic are the ſubſtances to which Silver and the other metals uſually owe their mineral ſtate. Theſe two matters are never very cloſely united with Silver; but may be pretty eaſily ſeparated from it by the action of fire, and the addition of Lead. If Arſenic be predominant in a Silver ore, it will unite with the Lead by the help of a pretty moderate heat, and quickly convert a conſiderable quantity thereof into a penetrating fuſible glaſs, which has the property of ſcorifying with eaſe all ſubſtances that are capable of ſcorification.

When Sulphur predominates, the ſcorification proceeds more ſlowly, and doth not always ſucceed; becauſe that mineral combined with Lead leſſens its fuſibility, and retards its vitrification. In this caſe, part of the Sulphur muſt be diſſipated by roaſting: the other part unites with the Lead; and that, being rendered lighter by this union, floats on the reſt of the mixture, which chiefly contains the Silver. At laſt, the joint action of the air and of the fire diſſipates the portion of Sulphur that had united with the Lead: the Lead vitrifies and reduces to a ſcoria whatever is not either Silver or Gold: and thus the Silver being diſentangled from the heterogeneous matters with which it was united, one part thereof being diſſipated and the other vitrified, combines with the portion of Lead which is not vitrified, and falls through the ſcoria, which, to favour its deſcent, muſt be in perfect fuſion.

The whole proceſs, therefore, conſiſts of three diſtinct operations. The firſt is Roaſting, which diſſipates ſome of the volatile ſubſtances found united with the Silver: the ſecond is Scorification, or the Vitrification of the fixed matters alſo united with the Silver, ſuch as ſand, ſtones, metals, *&c.* and the third is precipitation, or the ſeparation of the Silver from the ſcoria. The two firſt are, as hath been ſhewn, preparatives for the laſt, and indeed produce it.

As every thing we ſaid concerning Gold, when we treated of the proceſs of Amalgamation, is to be applied to Silver, which may be extracted by the ſame method when it is in its metalline form; in the ſame manner, all we now advance touching the method of extracting Silver by Scorification, when it is depraved with a mixture of heterogenous matters, is equally applicable to Gold in the ſame circumſtances: and indeed Silver almoſt always contains more or leſs Gold naturally.

In the proceſs we directed, that the ore ſhould be pulverized before it be expoſed to the fire, with a view to enlarge its ſurface, and by that means facilitate the action of the Lead upon it, as well as the evaporation of its volatile parts.

We recommended the precaution of ſlackening the fire a little at the beginning of the operation, only to prevent the Lead from being too haſtily converted into litharge, leſt it ſhould penetrate and corrode the teſt before it had wholly diſſolved the ore: but if we were perfectly certain of the veſſel's being ſo good as to be in no danger of penetration by the Lead, this precaution would be needleſs.

It is proper to add eight parts of Lead for one of ore; though ſo much is not always abſolutely neceſſary, eſpecially when the ore is very fuſible. The ſucceſs of this operation depends chiefly on the completeneſs of the Scorification; and therefore the addition of more Lead than enough is attended with no inconvenience: for, as it always promotes the Scorification, it can never do any harm.

If the ore be mixed with ſuch earthy and ſtony parts as cannot be ſeparated from it by waſhing, it is the more difficult

cult of fuſion, even though the ſtones ſhould be ſuch as are moſt diſpoſed to vitrify; becauſe the moſt fuſible earths and ſtones are always leſs ſo than moſt metallic ſubſtances. In that caſe it will be neceſſary, for effecting the Scorification, to mix thoroughly with the pulverized ore an equal quantity of Glaſs of Lead, to add twelve times as much granulated Lead, and then to proceed as directed for a fuſible ore; expoſing the mixture to a degree of fire ſtrong enough, and long enough kept up, to give the ſcoria all the properties above required as ſigns of a perfect ſcorification.

Silver ore is ſometimes mixed with Pyrites, and the ore of Arſenic, or Cobalt, which alſo make it refractory. As the Pyrites contain a large quantity of Sulphur, which is very volatile as well as Arſenic; in this caſe it is proper to begin with freeing the ore from theſe two extraneous ſubſtances. This is eaſily done by roaſting: only be ſure, when you firſt expoſe the ore to the heat, to cover the veſſel in which you roaſt it, for ſome minutes, with an inverted veſſel of the ſame width; becauſe ſuch ſorts of ore are very apt to fly when they firſt feel the heat.

After this uncover it, and leave it expoſed to the fire till no more ſulphureous or arſenical matters riſe. Then mix it with the ſame quantity of Glaſs of Lead as we ordered for ores rendered refractory by the admixture of earths or ſtones, and proceed in the ſame manner.

It is the more neceſſary to roaſt Silver ore infected with Sulphur and Arſenic, becauſe, as Sulphur obſtructs the fuſion of Lead, it cannot but do hurt, and protract the operation; and Arſenic does miſchief, on the other hand, by ſcorifying a very great quantity of Lead too haſtily.

When the Sulphur and Arſenic are diſſipated by roaſting, the ore muſt be treated like that which is rendered refractory by ſtony and earthy matters; for as the pyrites contain much iron, there remains, after the Sulphur is evaporated, a conſiderable quantity of martial earth, which is difficult to ſcorify. The pyrites, as well as the cobalts, contain moreover an unmetallic earth, which is hard to fuſe.

The general rule therefore is, when the ore is rendered refractory by any cauſe whatever, to mix it with Glaſs of Lead, and to add a larger quantity of granulated Lead. Yet ſome ores are ſo refractory that Lead alone will not do the buſineſs, and recourſe muſt be had to ſome other flux. That which is fitteſt for the preſent purpoſe is the *Black Flux*, compoſed of one part of Nitre and two parts of Tartar deflagrated together. The Phlogiſton contained in this quantity of Tartar is more than ſufficient to alkalizate the Nitre. This Flux, therefore, is nothing more than Nitre alkalizated by Tartar, mixed with ſome of the ſame Tartar that hath not loſt its Phlogiſton, and is only reduced to a ſort of coal.

The *White Flux* is alſo very fit to promote fuſion; but on this occaſion the Black Flux is preferable, becauſe the Phlogiſton of the Black Flux prevents the Lead from being too ſoon converted to litharge, and ſo gives it time to diſſolve the metallic matters. The White Flux, which is the reſult of equal parts of Tartar and Nitre alkalizated together, being no more than an Alkali deſtitute of Phlogiſton, or containing but very little, doth not poſſeſs this advantage.

If Silver ſhould be combined in the ore with Iron in its metalline ſtate, which however does not commonly happen, then, in order to ſeparate them, the Iron muſt be deprived of its Phlogiſton, and converted to a *crocus* before the mixed maſs be melted with Lead; which may be done by diſſolving it in the Vitriolic Acid, and then evaporating the Acid.

We are neceſſitated to make uſe of this contrivance, becauſe Iron in its metalline form cannot be diſſolved either by Lead or by the Glaſs of Lead; but when it is reduced to a calx, litharge unites with it and ſcorifies it.

If you have not at hand the utenſils neceſſary for performing the operation we have been deſcribing in a teſt, and under the muffle; or if you have a mind to work on a greater quantity of ore at a time, you may make uſe of a crucible for the purpoſe, and perform the operation in a melting furnace.

In this caſe the ore muſt be prepared, as above directed, according to its nature, and mixed with a proper quantity of Lead and Glaſs of Lead; the whole put into a good crucible, leaving two thirds thereof empty, and covered with a mixture of Sea-ſalt and a little Borax, both very dry, to the thickneſs of a full half inch.

This being done, ſet the crucible in the midſt of a melting furnace, raiſe the coals quite to the lip of the crucible; light the fire; cover the furnace with its dome; but do not urge the fire more than is neceſſary to bring the mixture to perfect fuſion: leave it thus in fuſion for a good quarter of an hour; ſtir the whole with a bit of ſtrong iron wire; then let it cool; break the crucible, and ſeparate the Regulus from the ſcoria.

The Salts added on this occaſion are fluxes, and their uſe is to procure a perfect fuſion of the ſcoria.

If the melted matters be left expoſed to the fire, either in a teſt or in a crucible, longer than is above preſcribed, the portion of Lead, that hath united and precipitated with the Silver, will at laſt vitrify, and at the ſame time ſcorify all the alloy with which that metal may be mixed. But as there are no veſſels that can long endure the action of litharge, without being pierced like a ſieve, ſome of the Silver may eſcape through the holes or fiſſures of the veſſel, and ſo be loſt. It is better, therefore, to complete the purification of your Silver by the operation of the Cupel, the deſcription of which follows.

PROCESS II.

The refining of Silver by the Cupel.

TAKE a cupel capable of containing one third more matter than you have to put into it: ſet it under the muffle of a furnace, like that deſcribed in our Theoretical Elements, as peculiarly appropriated to this ſort of operation. Fill the furnace with charcoal; light it; make the cupel red-hot, and keep it ſo till all its moiſture be evaporated; that is, for about a good quarter of an hour, if the cupel be made wholly of the aſhes of burnt bones; and for a whole hour, if there be any waſhed wood-aſh in its compoſition.

Reduce the Regulus which remained after the preceding operation to little thin plates, flatting them with a ſmall hammer, and ſeparating them carefully from all the adherent ſcoria. Wrap theſe in a bit of paper, and with a ſmall pair of tongs put them gently into the cupel. When the paper is conſumed the Regulus will ſoon melt, and the ſcoria, which will be gradually produced by the Lead as it turns to litharge, will be driven to the ſides of the cupel, and immediately abſorbed thereby. At the ſame time the cupel will aſſume a yellow, brown, or blackiſh colour, according to the quantity and nature of the ſcoria imbibed by it.

When you ſee the matter in the cupel in a violent ebullition, and emitting much ſmoke, lower the fire by the methods formerly preſcribed. Keep up ſuch a degree of heat only that the ſmoke which aſcends from the matter may not riſe very high, and that you may be able to diſtinguiſh the colour which the cupel acquires from the ſcoria.

Increaſe the fire by degrees, as more and more litharge is formed and abſorbed. If the Regulus examined by this aſſay contain no Silver, you will ſee it turn wholly into ſcoria, and at laſt diſappear. When it contains Silver, and the quantity of Lead is much diminiſhed, you will perceive little vivid iriſes, or beautiful rain-bow colours, ſhooting ſwiftly along its ſurface, and croſſing each other in many different directions. At laſt, when all the Lead is deſtroyed, the thin dark ſkin, that is continually protruded by the Lead while it is turning into litharge, and which hitherto covered the Silver, ſuddenly diſappears; and, if at this moment the fire happen not to be ſtrong enough to keep the Silver in fuſion, the ſurface of that metal will at once dart out a dazzling ſplendour: but, if the fire be ſtrong enough to keep the ſilver in fuſion, though freed from all mixture of Lead, this change of colour, which is called its *fulguration*, will not be ſo perceptible, and the Silver will appear like a bead of fire.

Theſe phenomena ſhew that the operation is finiſhed. But the cupel muſt ſtill be left a minute or two under the muffle, and then drawn ſlowly out with the iron hook towards the door of the furnace. When the Silver is ſo cooled as to be but moderately red, you may take the cupel from under the muffle with your little tongs, and in the middle of its cavity you will find an exceeding white bead of Silver, the lower part whereof will be unequal, and full of little pits.

OBSERVATIONS.

The Regulus obtained by the former proceſs conſiſts altogether of the Silver contained in the ore, alloyed with the other metals that happened to be mixed therewith in its mineral ſtate, and a good deal of the Lead that was added to precipitate the Silver. The operation of the cupel may be conſidered as the ſequel of that proceſs, being intended only to reduce into a ſcoria whatever is not Gold or Silver. Lead being of all metals that which vitrifies the moſt eaſily, which moſt promotes the vitrification of the reſt, and the only one which, when vitrified, penetrates the cupel, and carries along with it the other metals which it hath vitrified, is conſequently the fitteſt for that purpoſe. We ſhall ſee in its place, that Biſmuth hath the ſame properties with Lead, and may be ſubſtituted for it in this operation.

Care muſt be taken to chuſe a cupel of a proper capacity. Indeed it ſhould rather be too big than too little: becauſe the operation is no way prejudiced by an exceſs in its ſize;

whereas, if it be too ſmall, it will be over-doſed with Lead, and at laſt the litharge, which deſtroys every thing, will corrode its cavity, and eat holes through the very body of the veſſel. Add, that the aſhes, of which the cupel is made, being once glutted with litharge, abſorb it afterwards but ſlowly, and that the quantity of this vitrified litharge, becoming too great to be contained in the ſubſtance of the veſſel, exſudes through it, and drops on the floor of the muffle, which it corrodes and renders unequal; and moreover ſolders to it the veſſels ſet thereon. It may be laid down as a general rule for determining the ſize of a cupel, that it weigh, at leaſt, half as much as the metallic maſs to be refined in it.

It is alſo of the utmoſt conſequence that the cupel be well dried before the metal be put into it. In order to make ſure of this point, it muſt be kept red-hot for a certain time, as is above directed: for though to the ſight and to the touch it may appear very dry, it nevertheleſs obſtinately retains a ſmall matter of moiſture, ſufficient to occaſion the loſs of ſome of the metal; which, when it comes to melt, will be thereby ſpirited up, in the form of little globules, to the very roof of the muffle. The cupels that ſtand moſt in need of an intenſe heat to dry them, are thoſe chiefly in whoſe compoſition wood-aſhes are employed: for whatever care be taken to lixiviate thoſe aſhes before they are uſed, they will ſtill retain a little alkaline ſalt; and that, we know, is very greedy of moiſture, will not part entirely with it, but by the means of a violent calcination, and preſently re-imbibes it when expoſed to the air.

A little Phlogiſton alſo may ſtill be left in the aſhes of which the cupels are made; and that is another reaſon for calcining them before they are uſed. By this means the remaining Phlogiſton is diſſipated, which might otherwiſe combine with the litharge during the operation, reduce it, and occaſion ſuch a ferment in the matter as to make ſome of it run over; to theſe inconveniencies, which any remainder of moiſture or Phlogiſton may produce, we muſt add the cracks and flaws, which are very incident to cupels not perfectly freed from both thoſe matters.

It is of no leſs importance to the ſucceſs of this operation, that a due degree of heat be kept up. In the proceſs we have deſcribed the marks which ſhew the heat to be neither too ſtrong nor too weak; when it exceeds in either of theſe reſpects it may be known by the following ſigns.

If the fume emitted by the Lead riſe like a ſpout to the roof of the muffle; if the ſurface of the melted metal be extremely convex, conſidering the quantity of the maſs: if the cupel appear of ſuch a white heat, that the colour communicated thereto by the imbibed ſcoria cannot be diſtinguiſhed: all theſe ſhew that the heat is too great, and that it ought to be diminiſhed. If, on the contrary, the vapours only hover, as it were, over the ſurface of the metal; if the melted maſs be very flat, conſidering its quantity; if its ebullition appear but faint; if the *ſcoriæ*, that appear like little fiery drops of rain, have but a languid motion; if the ſcoria gather in heaps, and do not penetrate the cupel; if the metal be covered with it as with a glaſſy coat; and, laſtly, if the cupel look dull; theſe are proofs that the heat is too weak, and ought to be increaſed.

The deſign of this operation being to convert the Lead into litharge, and to give it ſufficient time and opportunity to ſcorify and carry off with it whatever is not Gold or Silver; the fire muſt be kept up to ſuch a degree that the Lead may eaſily be turned into litharge, and yet that litharge not be abſorbed too haſtily by the cupel, but that a ſmall quantity thereof may all along remain, like a ring, round the melted metal.

The fire is to be gradually increaſed as the operation draws nearer to its end: for, as the proportion of the Lead to the Silver is continually leſſening, the metallic maſs gradually becomes leſs fuſible; while the Silver defends the Lead mixed with it from the action of the fire, and prevents its being eaſily converted into litharge.

When the operation is finiſhed, the cupel muſt ſtill be left under the muffle, till it has imbibed all the litharge, to the end that the bead of Silver may be eaſily taken out: for, without this precaution, it would ſtick ſo faſt as not to be removed, but by breaking off part of the cupel along with it. Care muſt alſo be taken to let this bead of Silver cool gradually, and be perfectly fixed, before you draw it from under the muffle; for if you expoſe it at once to the cold air, before it be fixed, it will ſwell, ſhoot into ſprigs, and even dart out ſeveral little grains to a conſiderable diſtance, which will be loſt.

If the bead appear to have a yellowiſh tinge, it is a ſign that it contains a great deal of Gold, which muſt be ſeparated from it by the methods to be hereafter ſhewn.

It is proper to obſerve, that there is ſcarce any Lead that does not contain ſome Silver; too little perhaps to defray the charges neceſſary to ſeparate it, yet conſiderable enough to lead us into an error, by mixing with the Silver obtained from an ore, and increaſing its weight. And therefore, when the operations above deſcribed are applied to the aſſaying of an ore, in order to know how much Silver it yields, it is previouſly neceſſary to examine the Lead to be uſed, and to aſcertain the quantity of Silver it contains, which muſt be deducted from the total weight of the bead of Silver obtained by purifying it in this manner.

Silver may be ſeparated from its ore, and at the ſame time refined, by the ſingle operation of the cupel, without any previous ſcorification with Lead. In order to do this, you muſt pound the ore; roaſt it, to diſſipate all its volatile parts; mix it with an equal quantity of litharge, if it be refractory; divide it into five or ſix parcels, wrapping each in a bit of paper; weigh out eight parts of granulated Lead for one of ore, if it be fuſible, and from twelve to ſixteen, if it be refractory; put one half of the Lead into a very large cupel under the muffle; add thereto one of the little parcels of ore, when the Lead begins to ſmoke and boil; immediately ſlacken the fire a little; continue the ſame degree of heat till you perceive that the litharge formed round the metal, and on its ſurface, begins to look bright; then raiſe the fire; add a freſh parcel of ore; continue proceeding in the ſame manner till you have put in all the ore; then add the remaining half of the granulated Lead, and conduct the ſucceeding part of the operation in the ſame manner as that of cupelling.

In this operation it is neceſſary that the fire be not too ſtrongly urged, and that it be diminiſhed every time you add a freſh parcel of ore; that ſo the Lead and the litharge may have time to diſſolve, ſcorify, and carry off into the pores of the cupel, all the adventitious matters with which your Silver may be mixed. Notwithſtanding this precaution, when the ore is refractory, there often gathers in the cupel a great quantity of ſcoria, together alſo with ſome of the ore that could not be diſſolved and ſcorified. It is with a view to remedy this inconvenience that the ſecond moiety of the Lead is added towards the end, which completes the diſſolution and ſcorification of the whole; ſo that by means thereof no ſcoria, or very little, is left in the cupel at the end of the operation.

The operation of the cupel is chiefly uſed to purify Silver from the alloy of Copper; becauſe this metal, being more fixed and harder to calcine than other metallic ſubſtances, is the only one that remains united with Silver and Lead, after roaſting and ſcorification with Lead. It requires no leſs than ſixteen parts of the Lead to deſtroy it in the cupel, and ſeparate it from Silver. It melts into one maſs with the Lead;

and the glaſs produced by theſe two metals, deprived of their phlogiſton, inclines to a brown or a black colour; by which appearance chiefly we know that our Siver was alloyed with Copper.

PROCESS III.

To purify Silver by Nitre.

GRANULATE the Silver you intend to purify, or reduce it to thin plates; put it into a good crucible; add thereto a fourth part in weight of very dry pulverized Nitre, mixed with half the weight of the Nitre of calcined Wine-lees, and about a ſixth part of the ſame weight of common glaſs in powder. Cover this crucible with another crucible inverted; which muſt be of ſuch a ſize that its mouth may enter a little way into that of the lower one, and have its bottom pierced with a hole of about two lines in diameter. Lute the two crucibles together with clay and Windſor-loam. When the lute is dry, place the crucibles in a melting furnace. Fill the furnace with charcoal, taking care however that the fuel do not riſe above the upper crucible.

Kindle the fire, and make your veſſels of a middling-red heat. When they are ſo, take up with the tongs a live-coal, and hold it over the hole of the upper crucible. If you immediately perceive a vivid ſplendour round the coal, and at the ſame time hear a gentle hiſſing noiſe, it is a ſign that the fire is of a proper ſtrength; and it muſt be kept up at the ſame degree till this phenomenon ceaſe.

Then increaſe the fire to the degree requiſite to keep pure Silver in fuſion; and immediately after take your veſſels out of the furnace. You will find the Silver at the bottom of the lower crucible, covered with a maſs of Alkaline ſcoria of a greeniſh colour. If the metal be not rendered perfectly pure and ductile by this operation, it muſt be repeated a ſecond time.

OBSERVATIONS.

THE purification of Silver by Nitre, as well as the proceſs for refining it on the cupel, is founded on the property which this metal poſſeſſes of reſiſting the force of the ſtrongeſt fire, and the power of the moſt active ſolvents, without loſing its phlogiſton. The difference between theſe two operations

rations conſiſts wholly in the ſubſtances made uſe of to procure the ſcorification of the imperfect metals, or ſemi-metals, that may be combined with the Silver. In the former this was obtained by Lead, and here it is effected by Nitre. This Salt, as we have ſhewn, hath the property of calcining and quickly deſtroying all metallic ſubſtances, by conſuming their phlogiſton, except the perfect metals, Gold and Silver, which alone are able to reſiſt its force. This method may therefore be employed to purify Gold as well as Silver, or indeed both the two mixed together.

In this operation the Nitre is gradually alkalizated, as its Acid is conſumed with the phlogiſton of the metallic ſubſtances. The Alkaline Salt and pounded glaſs are added, with a view to promote the fuſion of the metalline calces, as faſt as they are formed, and to fix and retain the Nitre, which, as we ſhall preſently ſee, is apt to fly off in a certain degree of heat.

The precaution of covering the crucible with another crucible inverted, which hath only a ſmall hole in its bottom, is deſigned to prevent any of the Silver from being loſt in the operation: for when the Nitre comes to be acted on by a certain degree of heat, and eſpecially when it deflagrates with any inflammable matter, part of it flies off, and ſo rapidly too as to be capable of carrying off with it a good deal of the Silver. The little hole left in the covering crucible is neceſſary for giving vent to the vapours, which riſe during the deflagration of the Nitre, as they would otherwiſe open themſelves a paſſage by burſting the veſſels. After the operation this vent-hole is found beſet with many little particles of Silver, which would have been loſt if the crucible had not been covered.

If you ſhould obſerve, during the detonation of the Nitre, that a great many vapours iſſue through the vent-hole with a conſiderable hiſſing noiſe, even without applying the coal, you muſt take it for a ſign that the fire is too briſk, and accordingly check it; elſe a great deal of the Nitre will be diſſipated, and with it much Silver.

You muſt obſerve to take the Silver out of the fire as ſoon as it is in fuſion: for if you neglect this, the Nitre being entirely diſſipated or alkalizated, the calces of the metals deſtroyed by it may poſſibly recover a little phlogiſton, communicated either by the vapours of the charcoal, or by little bits of coal accidentally falling into the crucible; by which means ſome portion of thoſe metals being reduced will mix again with the Silver, prevent its having the deſired degree of purity and ductility, and oblige you to begin the operation afreſh.

PROCESS IV.

To diſſolve Silver in Aqua Fortis, *and thereby ſeparate it from every other metalline ſubſtance. The Purification of* Aqua Fortis. *Silver precipitated by Copper.*

THE Silver you intend to diſſolve being beaten into thin plates, put it into a glaſs cucurbit; pour on it twice its weight of good precipitated *aqua fortis;* cover the cucurbit with a piece of paper, and ſet it on a ſand-bath moderately heated. The *aqua fortis* will begin to diſſolve the Silver as ſoon as it comes to be a little warm. Red vapours will riſe; and from the upper ſurfaces of the Silver there will ſeem to iſſue ſtreams of little bubbles, aſcending to the top of the liquor, between which and the Silver they will form, as it were, a number of fine chains: this is a ſign that the diſſolution proceeds duly, and that the degree of heat is ſuch as it ought to be. If the liquor appear to boil and be agitated, a great many red vapours riſing at the ſame time, it is a ſign that the heat is too great, and ſhould be leſſened till it be reduced to the proper degree indicated above: having obtained that, keep it equally up till no more bubbles or red vapours appear.

If your Silver be alloyed with Gold, the Gold will be found, when the diſſolution is finiſhed, at the bottom of the veſſel in the form of a powder. This ſolution muſt now be decanted while it is yet warm; on the powder pour half as much freſh *aqua fortis* as before, and make it boil; again decant this ſecond *aqua fortis*, and repeat the ſame a third time; then with fair water waſh the remaining powder well: it will be of a brown colour inclining to red. In the obſervations we ſhall ſhow how the Silver is to be ſeparated from the *aqua fortis*.

OBSERVATIONS.

ALL the proceſſes on Silver already delivered, whether for extracting it from its ores, or for refining it, either by the Cupel or by Nitre, are applicable to Gold alſo. And if Silver be alloyed with Gold before it undergo thoſe ſeveral operations, it will ſtill remain alloyed therewith after them, in the ſame manner, and in the ſame quantity; becauſe both metals bear them equally. All therefore that can be expected from thoſe ſeveral aſſays, is the ſeparation of every thing that is neither Silver nor Gold from theſe two metals. But in order to ſeparate theſe two from each other, recourſe muſt be had either to the proceſs laid down under the head of Gold, or to that here deſcribed, which is the moſt commodious, the moſt uſual, and known by the names of *Quartation* and the *Parting Aſſay.*

Aqua fortis is the true ſolvent of Silver, and is utterly incapable of diſſolving the leaſt atom of Gold. If therefore a maſs conſiſting of Gold and Silver be expoſed to the action of *aqua fortis*, that Acid will diſſolve the Silver contained in the compound, without touching the Gold, and the two metals will be ſeparated from each other. This method of parting them is juſt the reverſe of that deſcribed before under the head of Gold, which is effected by the means of *aqua regis.*

To the ſucceſs of this ſeparation, by means of *aqua fortis*, ſeveral conditions are eſſentially neceſſary. The firſt is, that the Gold and Silver be in due proportion to each other; that is, there muſt be at leaſt twice as much Silver as Gold in the metalline maſs, otherwiſe the *aqua fortis* will not be able to diſſolve it, for the reaſon formerly given. If therefore the maſs contain too little Silver, it muſt either be melted down again, and a proper quantity of Silver added; or elſe, if the Gold be in a ſufficient proportion to the Silver, they may be parted by means of *aqua regis.*

Secondly, it is neceſſary that the *aqua fortis* employed in this operation be abſolutely pure, and free from any taint of the Vitriolic or Marine Acid: for, if it be adulterated with the Vitriolic Acid, the Silver will precipitate as faſt as it diſſolves, and ſo the precipitated Silver will again mix with the Gold. If the *aqua fortis* contain any of the Marine Acid, the Silver will be precipitated in that caſe alſo; and this inconvenience will be attended with another, namely, that the menſtruum, being partly an *aqua regis*, will diſſolve ſome of the Gold. You muſt therefore be very ſure that your *aqua fortis* is pure, before you ſet about the operation. In order to diſcover its quality, you muſt try it by diſſolving, in a ſmall portion thereof, as much Silver as it will take up: if the *aqua fortis* grow opaque and milky as it diſſolves the Silver, it is a ſign it contains ſome foreign Acid, from which it muſt be purified.

In order to effect this, let the portion of *aqua fortis* uſed for the above trial ſtand to ſettle: the white milky part will gradually fall to the bottom of the veſſel. When it is all fallen, gently decant the clear liquor, and pour a few drops of this decanted ſolution of Silver into the *aqua fortis* which you want to purify. It will inſtantly become milky. Let the white particles precipitate as before, and then add a few more drops of your ſolution of Silver. If the *aqua fortis* ſtill become milky, let it precipitate again, and repeat this till you find that a drop of your ſolution of Silver, let fall into this *aqua fortis*, does not make it in the leaſt turbid. Then filter it through brown paper, and you will have an *aqua fortis* perfectly fit for the Parting Aſſay.

The white particles that appear and ſettle to the bottom, on diſſolving ſilver in an *aqua fortis* adulterated with a mixture of ſome foreign Acid, are no other than that very Silver, which is no ſooner diſſolved by the Nitrous Acid than it deſerts that ſolvent to unite with the Vitriolic or Marine Acid, wherewith it has a greater affinity, and falls to the bottom with them. And this happens as long as there remains in the *aqua fortis* a ſingle atom of either of thoſe two Acids.

When therefore your *aqua fortis* hath diſſolved as much Silver as it is capable of taking up, and when all the white particles formed during the diſſolution are ſettled to the bottom, you may be aſſured that the portion which remains clear and limpid is a ſolution of Silver in an exceeding pure *aqua fortis*. But if the ſolution of Silver thus depurated be mixed with an *aqua fortis* adulterated with the Vitriolic or Marine Acid, a like precipitation will immediately enſue, for the reaſons above given, till the very laſt particle of the heterogeneous Acid contained in the *aqua fortis* be precipitated.

Aqua fortis purified by this method contains no extraneous ſubſtance whatever, except a ſmall portion of Silver; ſo that it is very fit for the parting proceſs. But if it be intended for other chymical purpoſes, it muſt be rectified in a glaſs retort with a moderate heat, in order to ſeparate it from the ſmall portion of Silver it contains, which will remain at the bottom of the retort.

The third condition neceſſary to the ſucceſs of this operation is, that your *aqua fortis* be neither too aqueous, nor too highly concentrated. If too weak, it will not act upon the Silver: and the conſequence will be the ſame if it be too ſtrong. Both theſe inconveniencies are eaſily remedied: for in the former caſe part of the ſuperfluous phlegm may be drawn off by diſtillation; or a ſufficient quantity of much ſtronger *aqua fortis* may be mixed with that which is too weak: and, in the latter caſe, very pure rain water, or a weaker *aqua fortis*, may be mixed with that which is too ſtrong.

You may ſatisfy yourſelf whether or no your *aqua fortis* hath the requiſite degree of ſtrength, by diſſolving therein a thin plate conſiſting of one part Gold and two or three parts Silver; which plate muſt be rolled up in form of a paper coffin. If, when all the Silver contained in the plate is diſſolved, the Gold remains in the form of the coffin, it is a ſign that your ſolvent has a due degree of ſtrength. If, on the contrary, the Gold be reduced to a powder, it is a proof that your *aqua fortis* is too ſtrong, and ought to be weakened.

The Gold remaining after the diſſolution of the Silver muſt be melted in a crucible with Nitre and Borax, as hath already been ſaid under the proceſs for parting Gold and Silver by means of *aqua regis*. As to the Silver which remains diſſolved in the *aqua fortis*, there are ſeveral ways to recover it.

The moſt uſual is to precipitate it by the interpoſition of Copper, which hath a greater affinity than Silver with the Nitrous Acid *. For this purpoſe the ſolution is weakened by adding twice or thrice as much very pure rain water. The cucurbit containing the ſolution is ſet on a ſand-bath gently heated, and very clean plates of copper put into it. The ſurfaces of theſe plates are ſoon covered with little white ſcales, which gradually fall to the bottom of the veſſel, as they come to be collected in quantities. It is even proper to ſtrike the cucurbit gently now and then, in order to ſhake the ſcales of Silver from the copper plates, and ſo make room for a new crop.

The *aqua fortis* parts with the Silver by degrees only, as it diſſolves the Copper; and therefore the liquor gradually acquires a blueiſh green colour as the precipitation advances. This precipitation of the Silver is to be continued as long as any remains diſſolved in the *aqua fortis*: you may be ſure that your liquor contains no more Silver, if the ſurface of a freſh plate of Copper laid therein remain clean and free from aſh-coloured or greyiſh particles: or if one drop of a ſolution of Sea-ſalt let fall into it produce no white or milky cloud.

The precipitation being finiſhed, the liquor is to be gently poured off from the precipitated Silver, which muſt be rinſed in ſeveral waters, and even made to boil therewith, in order to free it wholly from the diſſolved Copper. The Silver thus well waſhed muſt be thoroughly dried, mixed with a fourth part of its weight of a flux compounded of equal parts of Nitre and calcined Borax, and then melted in a crucible. On this occaſion care muſt be taken to raiſe the fire gently and gradually, till the Silver be brought to fuſion.

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* See the Table of Affinities, Column IV.

With what accuracy ſoever the precipitated Silver be waſhed, in order to free it from the ſolution of Copper, yet the Silver will always be found alloyed with a ſmall portion of the Copper: but then this Copper is eaſily deſtroyed by the Nitre, with which the Silver is afterwards melted; ſo that the latter metal remains perfectly pure after the operation.

Though the Silver be not previouſly cupelled, but be alloyed with other metallic ſubſtances at the time it is thus diſſolved, yet the diſſolving, precipitating, and fuſing it with Nitre, would be ſufficient to ſeparate it accurately from them all, and refine it to a degree of purity equal to that obtained by the cupel.

The Copper that remains diſſolved in the *aqua fortis*, after the precipitation of the Silver, may in like manner be precipitated by Iron, and, as it retains a ſmall portion of Silver, ought not to be neglected when theſe operations are performed on conſiderable quantities.

In the two next proceſſes we ſhall ſhew two other methods of ſeparating Silver from *aqua fortis*.

PROCESS V.

To ſeparate Silver from the Nitrous Acid by Diſtillation. Cryſtals of Silver. The Infernal Stone.

INTO a large, low, glaſs body put the ſolution of Silver, from which you intend to ſeparate the Silver by diſtillation. To this body fit a tubulated head provided with its ſtopple. Set this alembic in a ſand-bath, ſo that the body may be almoſt covered with ſand: apply a receiver, and diſtil with a moderate heat, ſo that the drops may ſucceed each other at the diſtance of ſome ſeconds. If the receiver grow very hot, check the fire. When red vapours begin to appear, pour into the alembic, through the hole in its head, a freſh quantity of your ſolution of Silver, firſt made very hot. Continue diſtilling in this manner, and repeating the addition of freſh liquor, till all your ſolution be put into the alembic.

lembic. When you have no more freſh ſolution to put in, and when, the phlegm being all come over, red vapours begin again to appear, convey into the alembic half a dram or a dram of tallow, and diſtil to dryneſs; which being done, increaſe your fire ſo as to make the veſſel containing the ſand-bath red-hot. In the alembic you will find a calx of Silver, which muſt be melted in a crucible with ſome ſoap and calcined wine-lees.

OBSERVATIONS.

A LOW cucurbit is recommended for this operation, to the intent that the particles of the Nitrous Acid, which are ponderous, may the more eaſily be carried up and paſs over into the receiver. For the ſame reaſon the cucurbit is directed to be almoſt wholly covered with ſand; leſt otherwiſe the acid vapours ſhould be condenſed about that part of the cucurbit, which, being out of the ſand, would be much cooler than that which is encompaſſed therewith, and from thence ſhould fall back again to the bottom; by which means the diſtillation would certainly be retarded, and the veſſel probably be broken.

Notwithſtanding theſe precautions the veſſels are liable to break in ſuch diſtillations; eſpecially when they contain a great deal of liquor. With a view, therefore, to prevent this accident, we ordered that the whole quantity of the ſolution of Silver to be diſtilled ſhould not be put at once into the alembic. The little bit of tallow, added towards the end of the operation, is intended to hinder the metal from adhering cloſely to the veſſel, as it would otherwiſe do, when all the moiſture is diſſipated.

The Soap and Fixed Alkali mixed with the Silver to flux it, after its ſeparation from the *aqua fortis* in this way, ſerve to abſorb ſuch of the moſt fixed particles of the Acid as may ſtill remain united with the metal.

If the diſtillation be ſtopped when part of the phlegm is drawn off, and the liquor be then ſuffered to cool, many cryſtals will ſhoot therein, which are a Neutral Salt conſtituted of the Nitrous Acid and Silver. If the diſtillation be carried further, and ſtopped when near its concluſion, the liquor being then ſuffered to cool will wholly coagulate into a blackiſh maſs called the *Infernal Stone.*

This way of ſeparating Silver from its ſolvent is attended with the advantage of ſaving all the *aqua fortis*, which is excellent, and fit to be employed in other operations.

PROCESS VI.

To ſeparate Silver from the Nitrous Acid by Precipitation. Luna Cornea. Luna Cornea *reduced.*

INTO your ſolution of Silver pour about a fourth part in weight of Spirit of Salt, ſolution of Sea-ſalt, or ſolution of Sal Ammoniac. The liquor will inſtantly become turbid and milky. Add twice or thrice its weight of fair water, and let it ſtand ſome hours to ſettle. It will depoſite a white powder. Decant the clear liquor, and on the precipitate pour freſh *aqua fortis*, or Spirit of Salt, and warm the whole on a ſand-bath with a gentle heat for ſome time. Pour off this ſecond liquor, and boil your precipitate in pure water, ſhifting it ſeveral times, till the precipitate and the water be both quite inſipid. Filter the whole, and dry the precipitate, which will be a *Luna Cornea*, and muſt be reduced in the following manner.

Smear the inſide of a good crucible well with ſoap. Put your *Luna Cornea* into it; cover it with half its weight of Salt of Tartar, thoroughly dried and pulverized; preſs the whole hard down; pour thereon as much oil, or melted tallow, as the powder is capable of imbibing; ſet the crucible thus charged, and cloſe covered, in a melting furnace, and, for the firſt quarter of an hour, make no more fire than is neceſſary to make the crucible moderately red: after that raiſe it ſo as to melt the Silver and the Salt, throwing into the crucible from time to time little bits of tallow. When it ceaſes to ſmoke, let the whole cool; or pour it into a hollow iron cone, warmed and tallowed.

OBSERVATIONS.

THE proceſs here delivered furniſhes us with the means of procuring Silver in a degree of purity which is not to be obtained by any other method of treating it whatever. That which is refined on the cupel always retains a ſmall portion of Copper, from which it cannot poſſibly be ſeparated in that way: but if it be diſſolved in *aqua fortis*, and precipitated thence in a *Luna Cornea* by the Marine Acid, the precipitate will be an abſolutely pure Silver, unalloyed with that ſmall portion of Copper which is retained on the cupel. The reaſon of this effect is, that the Copper remains as perfectly diſſolved in Spirit of Salt and in *aqua regia* as in *aqua fortis*: ſo that when the Silver, and the Copper with which it is alloyed, are diſſolved together in the Nitrous Acid, if the Acid of Sea-ſalt be mixed with the ſolution, part of this latter Acid unites with the Silver, and therewith forms a new compound, which not being ſoluble in the liquor, falls to the bottom. The other part of the Acid mixing with the Nitrous, forms an *aqua regis*, in which the Copper remains diſſolved, without ſeparating from it.

Freſh Acid is poured on the precipitated calx of Silver, in order to complete the ſolution of the ſmall portion of Copper that may have eſcaped the action of the firſt ſolvent. It is indifferent whether the Spirit of Salt or the Spirit of Nitre be employed for this purpoſe, becauſe they both diſſolve Copper alike, and becauſe Silver precipitated by Spirit of Salt is not ſoluble in either.

After this it is neceſſary to waſh the precipitate well with pure water, in order to free it entirely from the particles of *aqua fortis* adhering to the Silver; becauſe they may poſſibly contain ſomething of Copper, which would mix with the Silver in melting, and taint its purity.

If this precipitate of Silver be expoſed to the fire, unmixed with any other ſubſtance, it melts as ſoon as it begins to be red; and, if the fire be increaſed, part thereof will be diſſipated in vapours, and the reſt will make its way through the crucible. But being poured out as ſoon as melted, it coagulates into a cake of a purpliſh red colour, ſemi-tranſparent, ponderous, and in ſome degree pliable, eſpecially if it be very thin. It bears ſome reſemblance to horn, which hath occaſioned it to be called *Luna Cornea*.

As *Luna Cornea* is not ſoluble in water, recourſe muſt be had to fuſion, in order to reduce it, by ſeparating from the Silver thoſe acids which give it the above-mentioned properties. Fixed Alkalis and fatty matters are very fit to produce that ſeparation.

We directed that the inſide of the crucible, in which the reduction is to be made, ſhould be carefully ſmeared with ſoap, and that the *Luna Cornea* ſhould be quite covered with a Fixed Alkali and fat, to the end that when the heat is ſtrong enough to diſſipate it in vapours, or to attenuate it ſo as to render it capable of penetrating the crucible, it may be forced to paſs through matters qualified to abſorb its Acid, and reduce it.

Luna Cornea may alſo be reduced by being melted with ſuch metalline ſubſtances as have a greater affinity than Silver with the Acids wherewith it is impregnated. Of this kind are Tin, Lead, Regulus of Antimony: but the *Luna Cornea* ruſhes ſo impetuouſly into conjunction with thoſe metalline ſubſtances, that a vaſt many vapours ariſe, and carry off with them part of the Silver: if therefore you chuſe to effect the reduction by the interpoſition of ſuch metalline ſubſtances, you muſt employ a retort inſtead of a crucible.

But this method is attended with another inconvenience; which is, that ſome part of thoſe metalline ſubſtances may unite with the Silver, and adulterate it: for which reaſon it is beſt to keep to the method firſt propoſed.

PROCESS VII.

To diſſolve Silver, and ſeparate it from Gold, by Cementation.

MIX thoroughly together fine brick-duſt four parts, Vitriol calcined to redneſs one part, and Sea-ſalt or Nitre one part. Moiſten this powder with a little water. With this cement cover the bottom of a crucible half an inch thick; on this firſt bed lay a thin plate of the maſs of Gold and Silver you intend to cement, and which you muſt previouſly take care to beat into ſuch thin plates. Cover this plate with a ſecond layer of cement, of the ſame thickneſs as the former; on this ſecond bed lay another plate of your metal; cover it in like manner with cement; and ſo proceed till the crucible be filled to within half an inch of its brim. Fill up the remaining ſpace with cement, and cloſe the crucible with a cover, luted with a paſte made of Windſor-loam and water: ſet your crucible thus charged in a furnace, whoſe fire-place is deep enough to let it be entirely ſurrounded with coals, quite up to its mouth. Light ſome coals in the furnace, taking care not to make the fire very briſk at firſt; increaſe it by degrees, but only ſo far as to make the crucible moderately red; keep up the fire in this degree for eighteen or twenty hours: then let the fire go out; open the crucible when it is cold, and ſeparate the cement from your plates of Gold. Boil the Gold repeatedly in fair water, till the water come off quite inſipid.

OBSERVATIONS.

IT cannot but ſeem ſtrange, that, after having ſo often declared the Acid of Sea-ſalt to be incapable of diſſolving

Silver, we ſhould direct either Nitre or Sea-ſalt indifferently to be employed in compoſing a cement, which is to produce an Acid capable of eating out all the Silver mixed with Gold. It is eaſy to conceive how the Nitrous Acid extricated from its baſis by means of the Vitriolic Acid may produce this effect: but if Sea-ſalt inſtead of Nitre be made an ingredient in the cement, its Acid, though ſet at liberty in the ſame manner by the Vitriolic Acid, muſt at firſt ſight appear unable to anſwer the end.

In order to remove this difficulty, we muſt here obſerve, that there are two very eſſential differences between the Marine Acid collected in a liquor, as it is when diſtilled in the uſual manner, and the ſame Acid ſeparated from its baſis in a crucible, as it is in cementation.

The firſt of theſe two differences is, that the Acid being reduced into vapours when it acts on the Silver in cementation, its activity is thereby greatly increaſed: the ſecond is, that in the crucible it ſuſtains a vaſtly greater degree of heat than it can ever bear when it is in the form of a liquor. For, after it is once diſtilled and ſeparated from its baſis, it cannot ſuſtain any extraordinary degree of heat without being volatilized and entirely diſſipated: whereas, while it continues united with its baſis, it is much more fixed, and cannot be ſeparated but by a very intenſe heat. Conſequently, if it meet with any body to diſſolve, at the very inſtant of its ſeparation from its baſis, while it is actuated by a much fiercer heat than can ever be applied to it on any other occaſion, it muſt operate upon that body with ſo much the more efficacy: and thus it comes to paſs, that in cementation it has the power of diſſolving Silver, which it would be incapable of touching if it were not ſo circumſtanced.

But herein Gold differs from Silver: for, whatever force the Nitrous or the Marine Acid may exert, when extricated from their baſes in the cementing crucible, this metal obſtinately refuſes to yield to either of thoſe Acids ſeparately, and can never be diſſolved by them, unleſs both be united together.

Our cementation, therefore, is actually a parting proceſs in the dry way. The Silver is diſſolved, and the Gold remains unaltered. Nay, as the action of the Acids is much ſtronger when they are applied this way, than when they are uſed for diſſolution in the moiſt way, the Nitrous Acid, which in the common parting proceſs will not diſſolve Silver unleſs its weight be double that of the Gold, is able in cementation to diſſolve a very ſmall quantity of Silver diffuſed through a large quantity of Gold.

It ſometimes happens, that after the operation the cement proves extremely hard, ſo that it is very troubleſome to ſeparate it entirely from the Gold. In this caſe it muſt be ſoftened by moiſtening it with hot water. This hardneſs which the cement acquires is occaſioned by the fuſion of the Salts, which is the effect of too ſtrong a heat. It was in order to prevent this, and that a due degree of heat might be applied, without the danger of melting the ſalts, that we directed the cement to be mixed with a conſiderable quantity of earthy matter incapable of fuſion, ſuch as brick-duſt. A greater inconvenience will enſue, if the fire be made ſo ſtrong as to melt the Gold: for then it will partly commix again with the other metalline ſubſtances diſſolved by the cement, and conſequently will not be purified.

The crucible is covered, and its cover luted on, to prevent the acid vapours from being too ſoon diſſipated, and to force them to circulate the longer in the crucible. However, it is neceſſary that thoſe vapours ſhould find a vent at laſt, otherwiſe they would burſt the veſſel: and for this reaſon we directed the crucible to be luted only with Windſor-loam, which does not grow very hard by the action of fire, and ſo is capable of yielding and giving paſſage to the vapours, when a certain quantity of them is collected in the crucible, and they begin to ſtruggle for an eſcape on every ſide.

When the operation is finiſhed, the Silver diſſolved by the Acid of the cement is partly diſtributed through the cement, and partly in the Gold itſelf, which is impregnated therewith. For this reaſon the Gold muſt be waſhed ſeveral times in boiling water, till the water become abſolutely inſipid: for, if the Gold be melted without this precaution, it will mix again with the Silver: the cement alſo may be waſhed in the ſame manner to recover the Silver it contains.

Though this cementation be, properly ſpeaking, a purification of Gold, yet we have placed it among the proceſſes on Silver, becauſe it is the Silver that is diſſolved on this occaſion, and becauſe this is a particular way of diſſolving that metal. Moreover, moſt of the proceſſes hitherto delivered, either on Gold or Silver, are equally applicable to both theſe metals.

If the Gold do not appear quite pure after the cementation, the proceſs muſt be repeated.

There are ſeveral ways to know the fineneſs of Gold, the quantity of Silver with which it is alloyed, and the proportion

tion in which theſe two metals are mixed in a maſs purified by the cupel.

One of the ſimpleſt is the trial by the Touch-ſtone; which indeed is hardly any more than judging by the eye only, from the colour of the compound metal, what proportion of Gold and Silver it contains.

The Touch-ſtone is a ſort of black marble, whoſe ſurface ought to be half poliſhed. If the metalline maſs which you want to try be rubbed on this ſtone, it leaves thereon a thin coat of metal, the colour of which may be eaſily obſerved. Such as are accuſtomed to ſee and handle Gold and Silver can at once judge very nearly from this ſample in what proportion the two metals are combined: but, for greater accuracy, thoſe who are in the way of having frequent occaſion for this trial are provided with a ſufficient number of ſmall bars or needles, of which one is pure Gold, another pure Silver, and all the reſt conſiſt of theſe two metals mixed together in different proportions, varied by carats, or even by fractions of carats, if greater exactneſs be required.

The fineneſs of each needle being marked on it, that needle whoſe colour ſeems to come neareſt the colour of the metalline ſtreak on the Touch-ſtone, is rubbed on the ſtone by the ſide of that ſtreak. This needle likewiſe leaves a mark; and if there appear to be no difference between the two metalline ſtreaks, the metalline maſs is judged to be of the ſame fineneſs as the needle thus compared with it. If the eye diſcovers a ſenſible difference, another needle is ſought for whoſe colour may come nearer to that of the metal to be tried. But though a man be ever ſo well verſed in judging thus of the fineneſs of Gold by the eye only, he can never be perfectly and accurately ſure of it by this means alone. If ſuch certainty be required, recourſe muſt be had to the parting aſſay; and yet when you have gone through it, there always remains a ſmall quantity of the metal, which ſhould have been diſſolved, and yet eſcaped the action of the ſolvent. For example, if you make uſe of *aqua regis*, the Silver that remains after the operation ſtill contains a little Gold; and, if you make uſe of *aqua fortis*, the Gold that remains after the operation ſtill contains a little Silver. And therefore if you reſolve to carry the ſeparation of theſe two metals ſtill further by ſolvents, it will be neceſſary, after you have gone through one parting proceſs, to perform a ſecond the contrary way. For example, if you begin with *aqua fortis*, then, after it has diſſolved all the Silver in the metalline maſs that it is capable of taking up, diſſolve the remaining Gold in *aqua regis;* by which means you will ſeparate the ſmall portion of Silver left in it by the *aqua fortis.* The contrary is to be done if you made uſe of *aqua regis* firſt.

CHAP. III.

Of COPPER.

PROCESS I.

To ſeparate Copper from its Ore.

BEAT your Copper ore to a fine powder, having firſt freed it as accurately as poſſible, by waſhing and roaſting, from all ſtony, earthy, ſulphureous, and arſenical parts. Mix your ore thus pulverized with thrice its weight of the black flux; put the mixture into a crucible; cover it with common ſalt to the thickneſs of half an inch, and preſs the whole down with your finger. With all this the crucible muſt be but half full. Set it in a melting furnace; kindle the fire by degrees, and raiſe it inſenſibly till you hear the Sea-ſalt crackle. When the decrepitation is over, make the crucible moderately red-hot for half a quarter of an hour. Then give a conſiderable degree of heat, exciting the fire with a pair of good perpetual bellows, ſo that the crucible may become very red-hot, and be perfectly ignited. Keep the fire up to this degree for about a quarter of an hour; then take out the crucible, and with a hammer ſtrike a few blows on the floor whereon you ſet it. Break it when cold. If the operation hath been rightly and ſucceſsfully performed, you will find at the bottom of the veſſel a hard Regulus, of a bright yellow colour, and ſemi-malleable; and over it a ſcoria of a yellowiſh brown colour, hard and ſhining, from which you may ſeparate the Regulus with a hammer.

OBSERVATIONS.

COPPER in the ore is often blended with ſeveral other metallic ſubſtances, and with volatile minerals, ſuch as Sulphur and Arſenic. Copper ores alſo frequently participate of the nature of the pyrites, containing a martial and an unmetallic earth, both of which are entirely refractory, and hinder the ore from melting. In this caſe you muſt add equal parts of a very fuſile glaſs, a little borax, and four parts of the black flux, to facilitate the fuſion. The black flux is moreover neceſſary to furniſh the Copper with the Phlogiſton it wants, or reſtore ſo much thereof as it may loſe in melting. For the ſame reaſon, when any ore, but that of Gold or Silver, is to be ſmelted, it is a general rule to add ſome black flux, or other matter abounding with Phlogiſton.

The Regulus produced by this operation is not malleable, becauſe it is not pure Copper, but a mixture of Copper with all the other metallic ſubſtances that were in the ore; except ſuch as were ſeparated from it by roaſting, of which it contains but little.

According to the nature of the metallic matters that remain combined with the Copper after this fuſion, the colour of the Regulus is either like that of pure Copper, or a little more whitiſh: it is alſo frequently blackiſh, which has procured it the name of *Black Copper.* In this ſtate, and even in general, it is uſual enough to call this Regulus by the name of Black Copper, when alloyed with other metallic ſubſtances that render it unmalleable, whatever its colour be.

Hence it appears that there may be ſeveral different ſorts of Black Copper. Iron, Lead, Tin, Biſmuth, and the reguline part of Antimony, are almoſt always combined with the ores of Copper, in a multitude of different proportions; and all theſe ſubſtances, being reduced by the black flux in the operation, mix and precipitate with the Copper. If the ore contain any Gold or Silver, as is pretty often the caſe, theſe two metals alſo are confounded with the reſt in the precipitation, and become part of the Black Copper.

Pyritoſe, ſulphureous, and arſenical Copper ores may be fuſed, in order to get rid of the groſſer heterogeneous parts, without previouſly roaſting them: but in this caſe no alkaline flux muſt be mixed with the ore; becauſe the Alkali in combination with the Sulphur would produce a Liver of Sulphur, and ſo diſſolve the metalline part; by which means all would be confounded together, and no Regulus, or very little, be precipitated. On this occaſion therefore nothing muſt be added to promote the fuſion, but ſome tender fuſile glaſs, together with a ſmall quantity of borax.

This firſt fuſion may alſo be performed amidſt the coals, by caſting the ore upon them in the furnace, without uſing a crucible; and then an earthen veſſel, thoroughly heated, or even made red-hot, muſt be placed under the grate of the fire-place, to receive the metal as it runs from the ore.

The Regulus obtained by this means is much more impure and brittle than Black Copper, becauſe it contains moreover a large quantity of Sulphur and Arſenic; as theſe volatile ſubſtances have not time to evaporate during the ſhort ſpace requiſite to melt the ore, and as they cannot be carried off by the action of the fire after the ore is once melted, whatever time be allowed for that purpoſe. However, ſome part thereof is diſſipated; and the Iron which is in pyritoſe ores, having a much greater affinity than Copper, and indeed than any other metallic ſubſtance, with Sulphur and Arſenic, abſorbs another part thereof, and ſeparates it from the Regulus.

This Regulus, it is plain, ſtill contains all the ſame parts that were in the ore, but in different proportions; there being more Copper, combined with leſs Sulphur, Arſenic, and unmetallic earth, which have been either diſſipated or turned to ſlag. Therefore, if you would make it like Black Copper, you muſt pound it, roaſt it over and over, to free it from its Sulphur and Arſenic, and then melt it with the black flux.

If this Regulus contain much Iron, it will be adviſeable to melt it once or twice more, before all the Sulphur and Arſenic are ſeparated from it by roaſting; for as the Iron, by uniting with theſe volatile ſubſtances, ſeparates them from the Copper, with which they have not ſo great an affinity; ſo alſo the Sulphur and Arſenic, by uniting with the Iron, help in their turn to ſeparate it from the Copper.

PROCESS II.

To purify Black Copper, and render it malleable.

BREAK into ſmall bits the Black Copper you intend to purify; mix therewith a third part in weight of granulated Lead, and put the whole into a cupel ſet under the muffle in a cupelling furnace, and previouſly heated quite red. As ſoon as the metals are in the cupel raiſe the fire conſiderably, making uſe, if it be needful, of a pair of perpetual bellows, to melt the Copper ſpeedily. When it is thoroughly melted, lower the fire a little, and continue it juſt high enough to keep the metalline maſs in perfect fuſion. The melted matter will then boil, and throw up ſome *ſcoriæ*, which will be abſorbed by the cupel.

When moſt of the Lead is conſumed, raiſe the fire again, till the face of the Copper become bright and ſhining, thereby ſhewing that all its alloy is ſeparated. As ſoon as your Copper comes to this ſtate, cover it with charcoal-duſt conveyed into the cupel with an iron ladle: then take the cupel out of the furnace and let it cool.

OBSERVATIONS.

Of all the metals, next to Gold and Silver, Copper bears fuſion the longeſt without loſing its phlogiſton; and on this property is founded the proceſs here delivered for purifying it.

It is neceſſary the Copper ſhould melt as ſoon as it is in the cupel, becauſe its nature is to calcine much more eaſily and much ſooner, when it is only red-hot, than when it is in fuſion. For this reaſon the fire is to be conſiderably raiſed, immediately on putting the Copper under the muffle, that it may melt as ſoon as poſſible. Yet too violent a degree of fire muſt not be applied to it: for when it is expoſed to ſuch a degree of heat only as is but juſt neceſſary to keep it in fuſion, it is then in the moſt favourable condition for loſing as little as may be of its phlogiſton; and if the heat be ſtronger, a greater quantity thereof will be calcined. As ſoon therefore as it flows it is proper to weaken the fire, and reduce it to the degree juſt requiſite to keep up the fuſion.

The Lead added on this occaſion is intended to facilitate and expedite the ſcorification of the metallic ſubſtances combined with the Copper. So that the event is here nearly the ſame as when Gold or Silver is refined on the cupel. The only difference between this refining of Copper, and that of the perfect metals, is that the latter as hath been ſhewn, abſolutely reſiſt the force of fire and the action of Lead, without ſuffering the leaſt alteration; whereas a good deal of Copper is calcined and deſtroyed, when it is purified in this manner on the cupel. Indeed it would be wholly deſtroyed, if a greater quantity of Lead were added, or if it were left too long in the furnace. It is with a view to ſave as much of it as poſſible that we order it to be covered with charcoal-duſt as ſoon as the ſcorification is finiſhed.

The Lead ſerves moreover to free the Copper expeditiouſly from the Iron with which it may be alloyed. Iron and Lead are incapable of contracting any union together: ſo that as faſt as the Lead unites with the Copper, it ſeparates the Iron, and excludes it out of the mixture. For the ſame reaſon if Iron were combined in a large proportion with Copper, it would prevent the Lead from entering into the compoſition. Now, as it is neceſſary to give the more heat, and to keep the Copper to be incorporated with Lead the longer in fuſion, as that Copper is alloyed with a greater proportion of Iron, ſome black flux muſt be added on this occaſion, to prevent the Copper and the Lead from being calcined before their aſſociation can be effected.

Copper purified in the manner here directed is beautiful and malleable. It is now alloyed with no other metalline ſubſtance but Gold or Silver, if there were any in the mixed maſs. If you deſire to extract this Gold or Silver, recourſe muſt be had to the operation of the cupel. The proceſs here given for purifying Copper is not uſed in large works, becauſe it would be much too chargeable. In order to purify their Black Copper, and render it malleable, the ſmelters content themſelves with roaſting it, and melting it repeatedly, that the metallic ſubſtances, which are not ſo fixed as Copper, may be diſſipated by ſublimation, and the reſt ſcorified by fuſion.

PROCESS III.

To deprive Copper of its Phlogiſton by calcination.

PUT your Copper in filings into a teſt, and ſet it under the muffle of a cupelling furnace; light the fire, and keep up ſuch a degree of heat as may make the whole quite red, but not enough to melt the Copper. The ſurface of the Copper will gradually loſe its metalline ſplendour, and put on the appearance of a reddiſh earth. From time to time ſtir the filings with a little rod of copper or iron, and leave your metal expoſed to the ſame degree of fire till it be entirely calcined.

OBSERVATIONS.

IN our obſervations on the preceding proceſs we took notice that Copper, in fuſion, calcines more ſlowly, and leſs eaſily, than when it is expoſed to a degree of fire barely ſufficient to keep it red-hot, without melting it; and therefore, the deſign here being to calcine it, we have directed that degree of heat only to be applied.

The cupelling furnace is the fitteſt for this operation, becauſe the muffle is capable of receiving ſuch a flat veſſel as ought to be uſed on this occaſion, and communicating to it a great deal of heat; while, at the ſame time, it prevents the falling in of any coals, which, by furniſhing the Copper with freſh phlogiſton, would greatly prejudice and protract the operation.

As Copper calcines with great difficulty, this operation is extremely tedious: nay, though Copper hath ſtood thus expoſed to the fire for ſeveral days and nights, and ſeems perfectly calcined, yet it frequently happens that, when you try afterwards to melt it, ſome of it reſumes the form of Copper: a proof that all the Copper had not loſt its phlogiſton. Copper is much more expeditiouſly deprived of its phlogiſton by calcining it in a crucible with Nitre.

The calx of Copper perfectly calcined is with great difficulty brought to fuſion: yet, in the focus of a large burning-glaſs, it melts and turns to a reddiſh and almoſt opaque glaſs.

By the proceſs here delivered, you may likewiſe calcine all other metalline ſubſtances, which do not melt till they are thoroughly red-hot. As to thoſe which melt before they grow red, they are eaſily enough calcined, even while they are in fuſion.

PROCESS IV.

To reſuſcitate the Calx of Copper, and reduce it to Copper, by reſtoring its Phlogiſton.

MIX the Calx of Copper with thrice as much of the black flux; put the mixture into a good crucible, ſo as to fill two thirds thereof, and over it put a layer of Sea-ſalt a finger thick. Cover the crucible, and ſet it in a melting furnace; heat it gradually, and keep it moderately red till the decrepitation of the Sea-ſalt be over. Then raiſe the fire conſiderably by means of a good pair of perpetual bellows; ſatisfy yourſelf that the matter is in perfect fuſion, by dipping into the crucible an iron wire; continue the fire in this degree for half a quarter of an hour. When the crucible is cold, you will find at its bottom a button of very fine Copper, which will eaſily ſeparate from the ſaline ſcoria at top.

OBSERVATIONS.

WHAT hath been ſaid before on the ſmelting of Copper ores may be applied to this proceſs, as being the very ſame. The obſervations there added ſhould therefore be conſulted on this occaſion.

PROCESS V.

To diſſolve Copper in the Mineral Acids.

ON a ſand-bath, in a very gentle heat, ſet a matraſs containing ſome Copper filings; pour on them twice their weight of Oil of Vitriol. That Acid will preſently attack the Copper. Vapours will riſe, and iſſue out of the neck of the matraſs. A vaſt number of bubbles will aſcend from the ſurface of the metal to the top of the liquor, and the liquor will acquire a beautiful blue colour. When the Copper is diſſolved, put in a little and a little more, till you perceive the Acid no longer acts upon it. Then decant the liquor, and let it ſtand quiet in a cool place. In a ſhort time great numbers of beautiful blue cryſtals will ſhoot in it. Theſe cryſtals are called *Vitriol of Copper*, or *Blue Vitriol*. They diſſolve eaſily in water.

OBSERVATIONS.

THE Vitriolic Acid perfectly diſſolves Copper, which is alſo ſoluble in all the Acids, and even in many other menſtruums.

This Acid may be ſeparated from the Copper which it hath diſſolved by diſtillation only: but the operation requires a fire of the utmoſt violence. The Copper remaining after it muſt be fuſed with the black flux, to make it appear in its natural form; not only becauſe it ſtill retains a portion of the Acid, but alſo becauſe it hath loſt part of its phlogiſton by being diſſolved therein. The black flux is very well adapted both to abſorb the Acid that remains united with the Copper, and to reſtore the phlogiſton which the metal hath loſt.

The moſt uſual method of ſeparating Copper from the Vitriolic Acid is by preſenting to that Acid a metal with which it hath a greater affinity than with Copper. Iron being ſo qualified is conſequently very fit to bring about this ſeparation. When therefore plates of Iron well cleaned are laid in a ſolution of Blue Vitriol, the Acid ſoon begins to act upon them, and by degrees, as it diſſolves them, depoſites on their ſurfaces a quantity of Copper in proportion to the quantity of Iron it takes up. The Copper thus precipitated hath the appearance of ſmall leaves or ſcales, exceeding thin, and of a beautiful copper-colour. Care muſt be taken to ſhake the Iron-plates now and then, to make the ſcales of Copper fall off, which will otherwiſe cover them entirely, hinder the Vitriolic Acid from attacking the Iron, and ſo put a ſtop to the precipitation of the remaining Copper.

When theſe ſcales of Copper ceaſe to ſettle on the clean Iron plates, you may be ſure all the Copper that was in the liquor is precipitated, and that this liquor, which was a ſolution of Copper before the precipitation, is a ſolution of Iron after it. So that here two operations are performed at one and the ſame time; to wit, the precipitation of the Copper, and the diſſolution of the Iron.

The Copper thus precipitated requires only to be ſeparated from the liquor by filtration, and melted with a little black flux, to become very fine malleable Copper.

The Copper may alſo be precipitated out of a ſolution of Blue Vitriol by the interpoſition of a Fixed Alkali. This precipitate is of a greeniſh blue colour, and requires a much greater quantity of the black flux to reduce it.

Copper diſſolves in the Nitrous Acid, in the Marine Acid, and in *Aqua regis;* from all of which it may be ſeparated by the ſame methods as are here ordered with regard to the Vitriolic Acid.

CHAP.

CHAP. IV.

Of IRON.

PROCESS I.

To ſeparate Iron from its Ore.

POUND into a coarſe powder the martial ſtones or earths out of which you deſign to extract the Iron: roaſt this powder in a teſt under the muffle for ſome minutes, and let your fire be briſk. Then let it cool, beat it very fine, and roaſt it a ſecond time, keeping it under the muffle till it emit no more ſmell.

Then mix with this powder a flux compoſed of three parts of Nitre fixed with Tartar, one part of fuſile glaſs, and half a part of Borax and charcoal-duſt. The doſe of this reducing flux muſt be thrice the weight of the ore.

Put this mixture into a good crucible; cover it with about half a finger thick of Sea-ſalt; over the crucible put its cover, and lute it on with Windſor-loam made into a paſte with water. Having thus prepared your crucible, ſet it in a melting furnace, which you muſt fill up with charcoal. Light the fire, and let it kindle by gentle degrees, till the crucible become red-hot. When the decrepitation of the Sea-ſalt is over, raiſe your fire to the higheſt by the blaſt of a pair of perpetual bellows, or rather ſeveral. Keep up this intenſe degree of heat for three quarters of an hour, or an whole hour, taking care that during all this time the furnace be kept conſtantly filling up with freſh coals as the former conſume. Then take your crucible out of the furnace; ſtrike the pavement on which you ſet it ſeveral times with a hammer, and let it ſtand to cool: break it, and you will find therein a Regulus of Iron covered with ſlag.

OBSERVATIONS.

IRON ore, like all others, requires roaſting, to ſeparate from it, as much as poſſible, the volatile minerals, Sulphur and Arſenic, which being mixed with the Iron would render it unmalleable. Indeed it is ſo much the more neceſſary to roaſt theſe ores, as Iron is, of all metallic ſubſtances, that which has the greateſt affinity with thoſe volatile minerals; on which account no metallic ſubſtance whatever is capable of ſeparating it from them by fuſion and precipitation.

Fixed Alkalis, it is true, have a greater affinity than Iron with Sulphur; but then the compoſition which a Fixed Alkali forms with Sulphur is capable of diſſolving all metals. Conſequently, if you do not diſſipate the Sulphur by roaſting, but attempt to ſeparate it from the Iron by melting the ore with a Fixed Alkali, the Liver of Sulphur formed in the operation will diſſolve the martial part; ſo that after the fuſion you will find little or no Regulus.

All Iron ores in general are refractory, and leſs fuſible than any other; for which reaſon a much greater proportion of flux, and a much more violent degree of fire, is required to ſmelt them. One principal cauſe why theſe ores are ſo refractory is the property which Iron itſelf has of being extremely difficult to fuſe, and of reſiſting the action of the fire ſo much the more as it is purer, and further removed from its mineral ſtate. Among all the metallic ſubſtances it is the only one that is leſs fuſible when combined with that portion of phlogiſton which gives it the metalline form, than when it is deprived thereof, and in the form of a calx.

In ſmelting-houſes Iron ore is fuſed amidſt charcoal, the phlogiſton of which combines with the martial earth, and gives it the metalline form. The Iron thus melted runs down to the bottom of the furnace, from whence it is let out into large moulds, in which it takes the ſhape of oblong blocks, called *Pigs* of Iron. This Iron is ſtill very impure, and quite unmalleable. Its want of ductility after the firſt melting ariſes partly from hence, that, notwithſtanding the previous roaſting which the ore underwent, there ſtill remains, after this firſt fuſion, a conſiderable quantity of Sulphur or Arſenic combined with the metal.

A certain quantity of quick-lime, or of ſtones that will burn to lime, is frequently mixed with Iron ore on putting it into the ſmelting furnace. The lime being an abſorbent earth, very apt to unite with Sulphur and Arſenic, is of uſe to ſeparate thoſe minerals from the Iron.

It is alſo of uſe to mix ſome ſuch matters with the ore, when the ſtones or earths which naturally accompany it are very fuſible; for, as the Iron is of difficult fuſion, it may happen that the earthy matters mixed with the Iron ſhall melt as eaſily as the metal, or perhaps more eaſily. In ſuch a caſe there is no ſeparation of the earthy from the metalline part, both of which melt and precipitate together promiſcuouſly; now quick-lime, being extremely refractory, ſerves on this occaſion to check the melting of thoſe matters which are too fuſible.

Yet quick-lime, notwithſtanding its refractory quality, may ſometimes be of uſe as a flux for Iron. This is the caſe when the ore happens to be combined with ſubſtances which, being united with lime, render it fuſible: ſuch are all arſenical matters, and even ſome earthy matters, which being combined with quick-lime make a fuſible compound.

When the ore of an Iron mine is found difficult to reduce, it is uſually neglected even though it be rich: becauſe Iron being very common, people chuſe to work thoſe mines only whoſe ores are ſmelted with the moſt eaſe, and require the leaſt conſumption of wood.

Yet refractory ores are not to be altogether rejected, when another Iron ore of a different quality is found near them. For it often happens, that two ſeveral Iron ores, which being worked ſeparately are very difficult to manage, and yield at laſt but bad metal, become very tractable, and yield excellent Iron, when ſmelted together: and accordingly ſuch mixtures are often made at Iron-works.

The Iron obtained from ores by the firſt fuſion may be divided into two ſorts. The one, when cold, reſiſts the hammer, doth not eaſily break, and is in ſome meaſure extenſible on the anvil; but, if ſtruck with a hammer when red-hot, flies into many pieces: this ſort of Iron hath always a mixture of Sulphur in it. The other ſort, on the contrary, is brittle when cold, but ſomewhat ductile when red-hot. This Iron is not ſulphurated, is naturally of a good quality, and its brittleneſs ariſes from its metalline parts not being ſufficiently compacted together.

Iron abounds ſo much, and is ſo univerſally diffuſed through the earth, that it is difficult to find a body in which there is none at all: and this hath led ſeveral Chymiſts, even men of great fame, into the error of thinking that they had tranſmuted into Iron ſeveral ſorts of earths in which they ſuſpected no Iron, by combining them with an inflammable matter; whereas, in fact, all they did was to give the metalline form to a true martial earth which happened to be mixed with other earths.

PROCESS II.

To render Pig-iron and brittle Iron malleable.

INTO an earthen veſſel widening upwards put ſome charcoal-duſt, and thereon lay the Pig-iron which you propoſe to render ductile; cover it all over with a quantity of charcoal; excite the fire violently with a pair, or more, of perpetual bellows till the Iron melt. If it do not readily flow and form a great deal of ſlag on its ſurface, add ſome flux, ſuch as a very fuſible ſand.

When the matter is in fuſion keep ſtirring it from time to time, that all the parts thereof may be equally acted on by the air and the fire. On the ſurface of the melted Iron *ſcoriæ* will be formed, which muſt be taken off as they appear. At the ſame time you will ſee a great many ſparkles darted up from the ſurface of the metal, which will form a ſort of fiery ſhower. By degrees, as the Iron grows purer, the number of theſe ſparkles diminiſhes, though they never vaniſh entirely. When but few ſparkles appear, remove the coals which cover the Iron, and let the ſlag run out of the veſſel; whereupon the metal will grow ſolid in a moment. Take it out while it is ſtill red-hot, and give it a few ſtrokes with a hammer, to try if it be ductile. If it be not yet malleable, repeat the operation a ſecond time, in the ſame manner as before. Laſtly, when it is thus ſufficiently purified by the fire, work it for a long time on the anvil, extending it different ways, and making it red-hot as often as there is occaſion. Iron thus brought to the neceſſary degree of ductility, ſo as to yield to the hammer, and ſuffer itſelf to be extended every way, either hot or cold, without breaking to bits, or even cracking in the leaſt, is very good and very pure. If it cannot be brought to this degree by the method here preſcribed, it is a proof that the ore from which this Iron was extracted ought to be mixed with other ores; but it frequently requires a great number of trials to obtain an exact knowledge of the quality and proportion of thoſe other ores with which it is to be mixed.

OBSERVATIONS.

THE brittleneſs and ſhortneſs of Pig-iron ariſes from the heterogeneous parts which it contains, and which could not be ſeparated from it by the firſt fuſion. Theſe extraneous matters are uſually Sulphur, Arſenic, and unmetallic earth, and alſo a ferruginous earth; but ſuch as could not be combined with the phlogiſton as it ought to be, in order to have the properties of a metal, and muſt therefore be conſidered as heterogeneous, with reſpect to the other well-conditioned martial particles.

The Pig-iron, by undergoing repeated fuſions, is freed from thoſe heterogeneous matters; thoſe which are volatile, ſuch as Sulphur and Arſenic, being diſſipated, and the unmetallic matters being ſcorified. As to the ferruginous earth, which did not at firſt acquire the metalline form, it becomes true Iron at laſt; becauſe, among the coals with which it is encompaſſed, it meets with a ſufficient quantity of phlogiſton to reduce it to metal. Charcoal is alſo neceſſary on this occaſion, that it may continually furniſh phlogiſton to the Iron, which would otherways be converted into a calx.

Hammering the red-hot Iron, after each fuſion, ſerves to force out from amongſt the martial parts ſuch earthy matters as may happen to remain there, and ſo bring into cloſer contact the metalline parts which were ſeparated before by the interpoſition of thoſe heterogeneous matters.

PROCESS III.

To convert Iron into Steel.

TAKE ſmall bars of the beſt Iron; that is, of ſuch as is malleable both hot and cold; ſet them on their ends in a cylindrical earthen veſſel, whoſe depth is equal to the length of the bars, and in ſuch a manner that they may be an inch diſtant from each other, and from the ſides of the crucible. Fill the veſſel with a cement compounded of two parts of charcoal, one part of bones burnt in a cloſe veſſel till they become very black, and one half part of the aſhes of green wood; having firſt pulverized and thoroughly mixed the whole together. Take care to lift up the Iron bars a little, to the end that the cement may cover the bottom of the veſſel, and ſo that there be about the depth of half an inch thereof under every bar: cover the crucible and lute on the cover.

Set the crucible thus prepared in a furnace, ſo contrived that the crucible may be ſurrounded with coals from top to bottom: for eight or ten hours keep up ſuch a degree of fire that the veſſel may be moderately red; after this take it out of the furnace; plunge your little Iron bars into cold water, and you will find them converted into Steel.

OBSERVATIONS.

THE principal difference between Iron and Steel conſiſts in this, that the latter is combined with a greater quantity of phlogiſton than the former.

It appears by this experiment, that, to make Iron unite with an inflammable matter, it is not neceſſary it ſhould be in fuſion; it is ſufficient that it be ſo red-hot as to be opened and ſoftened by the fire.

Every kind of charcoal is fit to be an ingredient in the compoſition of the cement employed to make Steel, provided it contain no Vitriolic Acid. However, it hath been obſerved, that animal coals produce a ſpeedier effect than others: for which reaſon it is proper to mix ſomething of that kind with charcoal-duſt, as above directed.

The following ſigns ſhew that the operation hath ſucceeded, and that the Iron is changed into good Steel.

This metal being quenched in cold water, as propoſed above, acquires ſuch an extraordinary degree of hardneſs, that it will by no means yield to any impreſſion of the file or hammer, and will ſooner break in pieces than ſtretch upon the anvil. And here it is proper to obſerve, that the hardneſs of Steel varies with the manner in which it is quenched. The general rule is, that the hotter the Steel is when quenched, and the colder the water is in which you quench it, the harder it becomes. It may be deprived of the temper thus acquired, by making it red-hot, and letting it cool ſlowly; for it is thereby ſoftened, rendered malleable, and the file will bite upon it. For this reaſon the artiſans who work in Steel begin with untempering it, that they may with more eaſe ſhape it into the tool they intend to make. They afterwards new-temper the tool when finiſhed, and by this ſecond temper the Steel recovers the ſame degree of hardneſs it had acquired by the firſt temper.

The colour of Steel is not ſo white as that of Iron, but darker, and the grains, facets, or fibres, which appear on breaking it, are finer than thoſe obſerved in Iron.

If the bars of Iron thus cemented in order to convert them into Steel be too thick, or not kept long enough in cementation, they will not be turned into Steel throughout their whole thickneſs: their ſurfaces only will be Steel to a certain depth, and the center will be mere Iron; becauſe the phlogiſton will not have thoroughly penetrated them. On breaking a bar of this ſort, the difference in colour and grain between the Steel and the Iron is very viſible.

It is eaſy to deprive Steel of the ſuperabundant quantity of phlogiſton which conſtitutes it Steel, and thereby reduce it to Iron. For this purpoſe it need only be kept red-hot ſome time, obſerving that no matter approach it all the while that is capable of refunding to it the phlogiſton which the fire carries off. The ſame end is ſtill ſooner obtained by cementing it with meagre hungry matters, capable of abſorbing the phlogiſton; ſuch as bones calcined to whiteneſs, and cretaceous earths.

Steel may alſo be made by fuſion; or Pig-iron may be converted into Steel. For this purpoſe the ſame method muſt be employed as was above directed for reducing Pig-iron into malleable Iron; with this difference, that, as Steel requires more phlogiſton than is neceſſary to Iron, all the means muſt be made uſe of that are capable of introducing into the Iron a great deal of phlogiſton; ſuch as melting but a ſmall quantity of Iron at a time, and keeping it conſtantly encompaſſed with abundance of charcoal; reiterating the fuſions; taking care that the blaſt of the bellows directed along the ſurface of the metal do not remove the coals that cover it, *&c.* And here it muſt be obſerved, that there are ſome ſorts of Pig-iron which it is very difficult to convert into Steel by this method, and that there are others which ſucceed very readily, and with ſcarce any trouble at all. The ores which yield the laſt-mentioned ſort of Pig-iron are called *Steel Ores*. Steel made by this means muſt be tempered in the ſame manner as that made by cementation *.

PROCESS IV.

The Calcination of Iron. Sundry Saffrons of Mars.

TAKE filings of Iron, in what quantity you pleaſe; put them into a broad unglazed earthen veſſel; ſet it under the muffle of a cupelling furnace; make it red-hot; ſtir the filings frequently; and keep up the ſame degree of fire till the Iron be wholly turned into a red powder.

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* M. Réaumur hath obliged the public with a treatiſe on the means of converting Iron into Steel, in which he hath exhauſted the ſubject. Such as deſire the ampleſt and moſt uſeful inſtructions on that part of metallurgy, would do well to conſult his Work.

OBSERVATIONS.

Iron eaſily loſes its phlogiſton by the action of fire. The calx that remains after its calcination is exceeding red; which makes this be thought the natural colour of the earth of that metal. It hath accordingly been obſerved, that all the earths and ſtones which either are naturally red, or acquire that colour by calcination, are ferruginous.

The yellowiſh red colour which every calx of Iron hath, in whatever manner it be prepared, hath procured the name of *Crocus* or *Saffron* to every preparation of this kind. That made in the manner above directed is called in Medicine *Crocus Martis aſtringens.*

The ruſt produced on the ſurface of Iron is a ſort of calx of Iron made by way of diſſolution. The moiſture of the air acts upon the metal, diſſolves it, and robs it of ſome of its phlogiſton. This ruſt is called in Medicine *Crocus Martis Aperiens;* becauſe it is thought that the ſaline parts, by means whereof the humidity diſſolves the Iron, remain united with the metal after its diſſolution, and give it an aperitive virtue. The Apothecaries prepare this ſort of Saffron of Mars by expoſing Iron filings to the dew, till they be turned entirely to ruſt: which is then called *Saffron of Mars by dew.*

Another Saffron of Mars is alſo prepared in a much ſhorter manner, by mixing filings of Iron with pulverized Sulphur, and moiſtening the mixture, which after ſome time ferments and grows hot. It is then ſet on the fire; the Sulphur burns away, and the maſs is kept ſtirring till it become a red matter. This Saffron is nothing but Iron diſſolved by the Acid of Sulphur, which is known to be of the ſame nature with that of Vitriol; and conſequently this Saffron of Mars is no way differing from Vitriol calcined to redneſs.

PROCESS V.

Iron diſſolved by the mineral Acids.

PUT any mineral Acid whatever into a matraſs with ſome water; ſet the matraſs on a ſand-bath gently heated; drop into the veſſel ſome filings of Iron: the phenomena which uſually accompany metalline diſſolutions will immediately appear. Add more filings, till you obſerve the Acid hath loſt all ſenſible action upon them: then remove your matraſs from the ſand-bath; you will find in it a ſolution of Iron.

OBSERVATIONS.

IRON is very eaſily diſſolved by all the Acids. If you make uſe of the Vitriolic Acid, care muſt be taken to weaken it with water, in caſe it be concentrated; becauſe the diſſolution will ſucceed the better. The vapours that riſe on this occaſion are inflammable; and if a lighted paper be held to the mouth of the matraſs, eſpecially after keeping it ſtopt for ſome time and ſhaking the whole gently, the ſulphureous vapours take fire with ſuch rapidity as to produce a conſiderable exploſion; which is ſometimes ſtrong enough to burſt the veſſel into a thouſand pieces. This ſolution hath a green colour, and is in fact a fluid Green Vitriol, which wants nothing but reſt to make it ſhoot into cryſtals.

If you make uſe of the Nitrous Acid, you muſt ceaſe adding more filings when the liquor, after ſtanding ſtill ſome moments, becomes turbid; for, when this Acid is impregnated with Iron to a certain degree, it lets fall ſome of that which it had diſſolved, and becomes capable of taking up freſh filings. Thus, by conſtantly adding new ſupplies of Iron, this Acid may be made to diſſolve a much greater quantity thereof than is neceſſary to ſaturate it entirely. This ſolution is of a ruſſet colour, and doth not cryſtallize.

If the weather be not extremely cold, and the Acids have a proper degree of ſtrength, the ſand-bath is unneceſſary, as the diſſolution will ſucceed very well without it.

Iron diſſolved by Acids may be ſeparated therefrom, like all other metallic ſubſtances in the ſame circumſtances, either by the action of fire, which carries off the Acid and leaves the Martial Earth, or by the interpoſition of ſubſtances which have a greater affinity than metallic ſubſtances have with Acids; that is, by Abſorbent Earths and Alkaline Salts. By whatever means you ſeparate Iron from an Acid ſolvent, it conſtantly appears, after the ſeparation, in the form of a yellowiſh red powder; becauſe it is then deprived of moſt of the phlogiſton to which it owed its metalline form; whence it is reaſonable to think, that this is the proper colour of Martial earth.

All theſe precipitates of Iron are true Saffrons of Mars, which, as well as thoſe prepared by calcination, are ſo much the further removed from the nature of a metal, the more they are deprived of their phlogiſton. Thence it comes that they are more or leſs ſoluble by Acids, and more or leſs attracted by the magnet: as no ferruginous earth, perfectly deprived of all inflammable matter, is at all attracted by the magnet, or ſoluble by Acids.

CHAP. V.

Of TIN.

PROCESS I.

To extract Tin from its Ore.

BREAK your Tin ore into a coarſe powder, and by waſhing carefully ſeparate from it all the heterogeneous matters, and ores of a different kind, that may be mixed therewith. Then dry it, and roaſt it in a ſtrong degree of fire, till no more Arſenical vapour riſe from it. When the ore is roaſted, reduce it to a fine powder, and mix it thoroughly with twice its weight of the black flux well dried, a fourth part of its weight of clean iron filings, together with as much borax and pitch; put the mixture into a crucible; over all put Sea-ſalt to the thickneſs of four fingers, and cover the crucible cloſe.

Set the crucible thus prepared in a melting furnace: apply at firſt a moderate and ſlow degree of fire, till the flame of the pitch, which will eſcape through the joint of the cover, diſappear entirely. Then ſuddenly raiſe your fire, and urge it with rapidity to the degree neceſſary for melting the whole mixture. As ſoon as the whole is in fuſion take the crucible out of the furnace, and ſeparate the Regulus from the ſcoria.

OBSERVATIONS.

ALL Tin ores contain a conſiderable quantity of Arſenic, and no Sulphur at all, or at moſt very little. Hence it comes that, though Tin be the lighteſt of all metals, its ore is nevertheleſs much heavier than any other; Arſenic being much heavier than Sulphur, of which the ores of every other kind always contain a pretty large proportion. This ore is moreover very hard, and is not brought to a fine powder with ſo much eaſe as the reſt.

Theſe properties of Tin ore furniſh us with the means of ſeparating it eaſily by lotion, not only from earthy and ſtony parts, but even from the other ores which may be mixed with it. And this is of the greater advantage on two accounts, *viz.* becauſe Tin cannot endure, without the deſtruction of a great part thereof, the degree of fire neceſſary to ſcorify the refractory matters which accompany its ore; and again becauſe this metal unites ſo eaſily with Iron and Copper, the ores of which are pretty commonly blended with Tin ore, that, after the reduction, it would be found adulterated with a mixture of theſe two metals, if they were not ſeparated from it before the fuſion.

But ſometimes the Iron ore confounded with that of Tin is very heavy, and is not eaſily pulverized; whence it comes to paſs that it cannot be ſeparated therefrom by waſhing only. In that caſe the magnet muſt be employed to ſeparate it, after the ore hath been roaſted.

Roaſting is moreover neceſſary for Tin ore, in order to diſſipate the Arſenic which volatilizes, calcines, or deſtroys one part of the Tin, and reduces the reſt to a ſhort, brittle ſubſtance, like a Semi-metal. The ore is known to be ſufficiently roaſted when no more fumes riſe from it; when it has loſt the ſmell of garlic; and when it does not whiten a clean plate of Iron held over it.

Tin being one of thoſe metals which are moſt eaſily calcined, it is neceſſary in reducing its ore to employ ſuch matters as may furniſh it with phlogiſton. In order to defend it from the contact of the air, which always accelerates the calcination of metallic ſubſtances, the mixture is to be covered with Sea ſalt; and the addition of pitch helps to increaſe the quantity of phlogiſton.

PROCESS II.

The Calcination of Tin.

INTO an unglazed earthen diſh put the quantity of Tin you intend to calcine; melt it, and keep ſtirring it from time to time. Its ſurface will be covered with a greyiſh white powder: continue the calcination till all your Tin be converted into ſuch a powder, which is the *Calx of Tin.*

OBSERVATIONS.

THOUGH the calcination of metalline ſubſtances is promoted by expoſing them, in powder, or in filings, to the action of fire, and by ordering it ſo that they may not melt, becauſe they preſent a much ſmaller ſurface when melted than when unmelted; yet we have not directed this precaution to be uſed in calcining Tin. The reaſon is, this metal is ſo fuſible that it cannot endure the degree of fire requiſite to deſtroy its phlogiſton without melting, and of courſe, though Tin calcines eaſily, the operation is nevertheleſs tedious, becauſe the melted metal preſents but a ſmall ſurface to be acted on by the fire and the air. This inconvenience may be partly remedied, and the operation greatly expedited, by dividing the quantity of Tin to be calcined into ſeveral ſmall parcels, and expoſing them to the fire in ſeparate veſſels, ſo that they may not re-unite when melted, and form one ſingle maſs.

Leaf Tin caſt on Nitre in actual fuſion cauſes it to deflagrate and fulminate; and from this mixture there riſes a white vapour, which is converted into flowers when it meets with any obſtacle to impede its flying off entirely.

Mr. Geoffroy, who went through a courſe of experiments on Tin, an account whereof may be ſeen in the Memoirs of the Academy of Sciences, found that from the colour of the calx of that metal a judgment may be formed of its degree of purity, and nearly of the quantity and quality of the metallic ſubſtances with which it is alloyed. The experiments tried on this ſubject by that eminent Chymiſt are very curious.

He performed the calcination in a crucible, which he heated to a cherry-red, and kept up the ſame degree of fire from the beginning to the end of the operation. The calx which formed upon his metal, in that degree of heat, appeared like ſmall white ſcales, a little reddiſh on the under ſide. He puſhed it to one ſide as it formed, to the end that it might not cover the ſurface of the metal, which, like all others, requires the contact of the air to turn it into a calx.

" While he was making theſe calcinations, he had an op-
" portunity of obſerving a curious fact, of which no body
" before him had ever taken notice; probably becauſe no
" body had ever calcined Tin by the ſame method. The
" fact

“ fact is, that during the calcination of the Tin, whether “ you break the pellicle which forms on the ſurface of the “ metal while in red-hot fuſion, or whether you let it re-“ main without touching it, you perceive in ſeveral places a “ ſmall ſwell of a certain matter, which burſts and makes “ its way through the pellicle. This matter puffs up, grows “ red, at the ſame inſtant takes fire, and darts out a ſmall “ whitiſh flame, as vivid and as brilliant as that of Zinc, “ when urged by a fire ſtrong enough to ſublime it into “ flowers. The vividneſs of this flame may be further com-“ pared to that of ſeveral ſmall grains of phoſphorus of “ urine fired and gently dropped on boiling water. From “ this bright flame a white vapour exhales; after which the “ ſwelled maſs partly crumbles down, and turns to a light “ white powder, ſometimes ſpotted with red, according to “ the force of the fire. After this momentary ignition, “ there ariſe ſtronger, more numerous, or more frequent “ heavings of matter, out of which iſſues a good deal of “ white fume, that may be intercepted by a cover of tin-“ plate or copper fitted to the crucible, and appears to be “ the flowers of Tin, which in ſome meaſure corrode theſe “ metals. Hence Mr. Geoffroy conjectures, with a great “ deal of probability, that their ſublimation is promoted by “ a portion of Arſenic. When the cruſt formed by this calx “ comes to be too thick, or in too great a quantity, to be “ puſhed on one ſide, ſo as to leave part of the metal unco-“ vered, Mr. Geoffroy puts out the fire, becauſe no more “ calx would be formed: the communication of the external “ air with the Tin in fuſion being abſolutely neceſſary there-“ to, as hath been already ſaid. In this operation it is to “ be obſerved that, if the fire be too ſlow, neither the in-“ flammation of the ſulphureous particles, nor the white “ fumes that riſe, will be ſo diſtinctly perceived, as when “ the fire is of the degree requiſite to keep the crucible juſt “ of a cherry-red heat.

“ Mr. Geoffroy having taken off this firſt calx began the “ calcination anew. In this ſecond heat the buddings or “ heavings were more conſiderable, and ſhot up in the form “ of cauli-flowers; but were ſtill compoſed of little ſcales. “ The thoroughly calcined portion of this vegetation was “ likewiſe white and red; and the inferior ſurfaces of ſome “ little bits thereof were wholly red. When theſe calcina-“ tions are continued, ſulphureous vapours riſe ſeemingly of “ another kind than thoſe which appeared in the beginning; “ for all the calx made by the firſt heat was perfectly white:

" whereas in the ſecond it begins to be ſpotted here and
" there with a tinge of black. Mr. Geoffroy was obliged
" to go through a courſe of twelve ſeveral calcinations be-
" fore he could convert two ounces of Tin into a calx. He
" had the opportunity, during theſe ſeveral calcinations, to
" obſerve that after the fourth, and ſometimes after the third,
" the red ſpots of the calx decreaſe, and the black increaſe;
" that the germinations ceaſe; that the cruſt of the calx re-
" mains flat; that in the twelfth fire the Tin yields no more
" of this ſcaly cruſt; that towards the end the undulations
" of the fuſed metal appear no longer; and that the ſmall
" remainder of calx is mixed with ſeveral very minute
" grains of metal, which ſeem much harder than Tin. Mr.
" Geoffroy could not collect a ſufficient quantity thereof
" to cupel them, and ſatisfy himſelf whether or no they
" were Silver."

Though Tin, and all the imperfect metals in general, ſeem converted to a calx, and loſe the metalline form, by one ſingle calcination, and that a ſlight one; yet they are not wholly deprived of their phlogiſton: for if the calx of Tin, for inſtance, prepared according to the proceſs above delivered, be caſt upon Nitre in fuſion, it will make that ſalt deflagrate very perceptibly; a convincing proof that it ſtill contains much inflammable matter. If therefore a calx be required abſolutely free from phlogiſton, this firſt calx muſt be re-calcined by a more violent fire, and the calcination continued till all the phlogiſton be diſſipated.

" Mr. Geoffroy, being deſirous of having his calx of Tin
" very pure and perfectly calcined, expoſed once more to
" the action of fire the twelve portions of calx obtained by
" his former calcinations. But, as it would have been too
" tedious to re-calcine them all ſeparately, he made four
" parcels of the whole, each conſiſting of three taken ac-
" cording to the order in which they were firſt calcined; and
" gave to each a fire ſufficiently ſtrong, and long enough
" continued, to calcine them as thoroughly as was poſſible.
" After this ſecond calcination he found them all of a moſt
" beautiful white, except the firſt parcel: as that conſiſted
" of the portions obtained by the three firſt heats, in all of
" which there were ſcales tinged with red, it ſtill retained a
" ſtain of carnation, though hardly perceptible. Agreeably
" to the general rule, the two ounces of Tin gained in
" weight by being thus calcined; and the increaſe was two
" drams and fifty ſeven grains.

" Mr. Geoffroy obſerves, that no Tin, but what is abſo-" lutely pure, will yield a perfectly white calx. He calcin-" ed in this manner ſeveral other parcels of Tin that were " impure and variouſly alloyed; each of which produced a " calx differently coloured, according to the nature and " quantity of its alloy: whence he juſtly concludes, that " calcination is a very good method of trying the fineneſs " of Tin, or its degree of purity." The particulars of Mr. Geoffroy's experiments on this ſubject, which are very curious, may be ſeen in the Memoirs of the Academy for 1738.

It is proper to take notice that a man ſhould be very cautious how he expoſes himſelf to the vapours of Tin, becauſe they are dangerous; this metal being very juſtly ſuſpected by Chymiſts of containing ſomething Arſenical.

PROCESS III.

The diſſolution of Tin by Acids. The Smoking Liquor of Libavius.

PUT into a glaſs veſſel what quantity you pleaſe of fine Tin cut into little bits. Pour on it thrice as much *aqua regis*, compounded of two parts *aqua fortis* weakened with an equal quantity of very pure water, and one part Spirit of Salt. An ebullition will ariſe, and the Tin will be very rapidly diſſolved; eſpecially if the quantities of metal and of *aqua regis* be conſiderable.

OBSERVATIONS.

TIN is ſoluble by all the Acids; but *aqua regis* diſſolves it beſt of any. Yet in this diſſolution it comes to paſs that part of the diſſolved Tin precipitates of its own accord to the bottom of the veſſel, in the form of a white powder. This ſolution of Tin is very fit for preparing the purple-coloured precipitate of Gold. For this purpoſe the ſolution of Tin muſt be let fall, drop by drop, into a ſolution of Gold. Spirit of Nitre diſſolves Tin nearly as *aqua regis* does; but it occaſions a greater quantity of calx.

If two or three parts of Oil of Vitriol be poured on one part of Tin, and if the veſſel in which the mixture is made be expoſed to ſuch a degree of heat as to evaporate all the moiſture, there will remain a tenacious matter ſticking to the ſides of the veſſel. If water be poured on this matter, and it be then expoſed a ſecond time to the fire, it will diſſolve entirely, excepting a ſmall portion of a glutinous ſubſtance, which alſo may be diſſolved in freſh Oil of Vitriol.

The Acid of Sea-ſalt may be combined with Tin by the following proceſs. Mix perfectly, by trituration in a marble mortar, an amalgam of two ounces of fine Tin, and two ounces and a half of Quick-ſilver, with as much Corroſive Sublimate. As ſoon as the mixture is completed, put it into a glaſs retort, and diſtil with the ſame precautions as we directed to be uſed in preparing concentrated and ſmoking Acids. There will firſt come over into the receiver ſome drops of a limpid liquor, which will be ſoon followed by an elaſtic ſpirit that will iſſue out with impetuoſity. At laſt ſome flowers, and a ſaline tenacious matter, will riſe into the neck of the retort. Then ſtop your diſtillation, and pour into a glaſs bottle the liquor you will find in the receiver. This liquor continually exhales a conſiderable quantity of denſe, white fumes, as long as it is allowed to have a free communication with the air.

The product of this diſtillation is a combination of the Acid of Sea-ſalt with Tin. As the affinity of Tin with this Acid is greater than that of Mercury, the Acid contained in the Corroſive Sublimate quits the Mercury, wherewith it was united, to join the Tin; which it volatilizes ſo as to make it riſe with itſelf in a limpid form. We make uſe of the amalgam of Tin with Quick-ſilver, becauſe we are thereby enabled to mix the Corroſive Sublimate perfectly therewith, as the ſucceſs of the operation requires it ſhould be.

In this experiment the Tin is volatilized, and the Acid of Sea-ſalt, which is exceedingly concentrated, flies off inceſſantly in the form of white vapours. This compound is known in Chymiſtry by the name of *Smoking Liquor of Libavius;* a name derived from its quality, and from its Inventor. Tin diſſolved by Acids is eaſily ſeparated from them by Alkalis. It always precipitates in the form of a white calx.

CHAP.

CHAP. VI.

Of LEAD.

PROCESS I.

To extract Lead from its Ore.

HAVING roaſted your Lead ore reduce it to a fine powder; mix it with twice its weight of the black flux, and one fourth of its weight of clean iron filings and borax; put the whole into a crucible capable of containing at leaſt thrice as much; over all put Sea-ſalt four fingers thick; cover the crucible; lute the juncture; dry the whole with a gentle heat, and ſet it in a melting furnace.

Make the crucible moderately red: you will hear the Sea-ſalt decrepitate, and after the decrepitation a ſmall hiſſing in the crucible. Keep up the ſame degree of fire till that be over.

Then throw in as many coals as are neceſſary to complete the operation entirely, and raiſe the fire ſuddenly, ſo as to bring the whole mixture into perfect fuſion. Keep up this degree of fire for a quarter of an hour, which is time ſufficient for the precipitation of the Regulus.

When the operation is finiſhed, which may be known by the quietneſs of the matter in the crucible, and by a bright vivid flame that will riſe from it, take the crucible out of the furnace, and ſeparate the Regulus from the ſcoria.

OBSERVATIONS.

ALL Lead ore contains a good deal of Sulphur, which muſt be firſt ſeparated from it by roaſting: and as this kind of ore is apt to fly when firſt expoſed to the fire, it is proper to keep it covered till it be thoroughly heated. Another precaution to be uſed, in roaſting this ore, is not to give it too great a heat, but to keep the veſſel which contains it juſt moderately red; becauſe it eaſily turns clammy, which occaſions it to ſtick to the veſſel.

The Iron that is added, and mixed with the flux, abſorbs the Sulphur which may happen to remain, even after roaſting: it helps alſo to ſeparate from the Lead ſome portions of ſemi-metal, eſpecially of Antimony, which are frequently mixed with this ore.

There is no fear leaſt the Iron mix with the Lead in fuſion, and adulterate it: for theſe two metals are incapable of contracting any union together, when each has its metalline form.

Nor is there any reaſon to apprehend leſt the Iron ſhould, by its refractory quality, obſtruct the fuſion of the mixture; for though this metal be not fuſible when alone, yet, by the union it contracts with the matters it is deſigned to abſorb, it becomes ſo to ſuch a degree as in ſome meaſure to perform, on this occaſion, the office of a flux.

The government of the fire is a point of great conſequence in this operation. It is neceſſary to apply but a moderate degree of heat at firſt: for, when the metallic earth of the Lead, combining with the phlogiſton, acquires the metalline form, it ſwells up in ſuch an extraordinary manner, that there is great danger leaſt the matter ſhould overflow, and run all out of the containing veſſel. With a view therefore to avoid this inconvenience, we direct a very large crucible to be uſed. This heaving of the Lead, at the inſtant of its reduction, is attended with a noiſe like the whiſtling of wind.

Notwithſtanding all the precautions that can be uſed to prevent the reduction from taking place too haſtily, and ſo occaſioning the effuſion of the matter, it often happens that, on raiſing the fire in order to bring the mixture into fuſion, the hiſſing ſuddenly begins again, and is very loud. In that caſe all the apertures of the furnace muſt immediately be ſhut cloſe, in order to choak and ſuffocate the fire: for, if this be neglected, the matter in the crucible will ſwell up, make its way through the luting of the juncture, nay, puſh up the cover, and run over. This accident is to be apprehended during the firſt five or ſix minutes after you raiſe the fire in order to melt the mixture. This effuſion of the matter is accompanied with a dull flame, a thick, grey and yellow ſmoke, and a noiſe like that of ſome boiling liquor. When you obſerve theſe ſeveral phenomena you may be ſure the matter is run out of the crucible, either in the manner above deſcribed, or by making its way through ſome cracks in the veſſel, and conſequently that the operation is ſpoiled.

Moreover, this event infallibly follows whenever a bit of coal happens to fall into the crucible; and this is one reaſon why it is neceſſary to cover it.

You may be certain that the operation hath ſucceeded if the ſcoria be ſmooth when cold, and have not in part eſcaped through the lute; if the Lead be not diſperſed in globules through the whole maſs of the matter contained in the crucible, but is, on the contrary, collected at the bottom, in the form of a ſolid Regulus, not very ſhining, but of a blueiſh caſt, and ductile. Moreover, the ſcoria ought, in the preſent caſe, to be hard and black, and ſhould not appear full of holes like a ſieve, except only in that part which was contiguous to the Salt.

Here it is proper to obſerve, that the Sea-ſalt doth not mix with the ſcoria, but floats upon it. After the operation it is black; which colour it gets, no doubt, from the charred parts of the flux. The abſence of theſe ſigns ſhews the operation to have miſcarried.

When the ore to be ſmelted is pyritoſe and refractory, it may be roaſted at firſt with a much ſtronger degree of fire than is uſed for ores that are fuſible; becauſe the martial earth, and the unmetallic earth, which are always mixed in pyritoſe matters, hinder it from growing readily ſoft in the fire. Beſides, ſuch an ore requires a greater quantity of the black flux and of borax to be mixed with it, and a higher degree of fire to fuſe it.

It is generally needleſs to mix iron filings with this ſort of ore; becauſe the martial earth, with which pyritoſe matters are always accompanied, is reduced during the operation by the help of the black flux, which for that purpoſe is mixed with it in a large proportion, and furniſhes a quantity of iron ſufficient to abſorb the heterogeneous minerals mixed with the Lead.

Yet, if it ſhould be obſerved that the pyrites which accompany the Lead ore are arſenical, then, as ſuch pyrites contain but a ſmall quantity of ferruginous earth, iron filings muſt be added; which are, on this occaſion, ſo much the more neceſſary for abſorbing the Arſenic, as this mineral remains in part confounded with the ore, is reduced to a Regulus during the operation, unites with the Lead, and deſtroys a great deal of it by procuring its vitrification.

The Lead obtained from ſuch pyritoſe ores is commonly not very pure; it is blackiſh and ſcarce ductile; qualities communicated to it by a ſmall mixture of Copper in the pyrites,

rites, which always contain more or leſs thereof. We ſhall preſently ſhew the method of ſeparating Lead from Copper.

Lead ore may alſo be reduced by melting it amidſt coals. For that purpoſe firſt kindle a fire in the furnace in which you intend to melt your ore; then put a layer of your ore immediately upon the lighted coals, and cover it with another layer of coals.

Though the melting furnace uſed for this operation be capable of giving a conſiderable heat, yet it is neceſſary further to increaſe the force of the fire by the means of a good pair of perpetual bellows, which will produce an effect like that of a forge. The ore melts, the earth of the Lead unites with the phlogiſton of the coals, and ſo is reduced to metal, which runs through the coals, and falls into an earthen veſſel placed at the bottom of the furnace to receive it. Care muſt be taken to keep this veſſel well filled with charcoal-duſt, to the end that the Lead may be in no danger of calcination while it continues there; the charcoal-duſt conſtantly furniſhing it with phlogiſton to preſerve its metalline form.

The earthy and ſtony matters that accompany the ore are ſcorified by this fuſion, juſt as they are by the other which is performed in a cloſe veſſel. With regard to the Sulphur and Arſenic, they are ſuppoſed to have been firſt accurately ſeparated from the ore by roaſting. This is the method commonly employed for ſmelting Lead ore at the works.

PROCESS II.

To ſeparate Lead from Copper.

WITH luting earth and charcoal-duſt make a flat veſſel, widening upwards, and large enough to contain your metalline maſs. Set it ſhelving downwards from the back towards the fore-part; and in the fore-part, at the bottom, make a little gutter communicating with another veſſel of the ſame nature, placed near the former and a little lower. Let the mouth of the gutter within ſide the upper veſſel be narrowed, by means of a ſmall iron plate fixed acroſs it, while the loam is yet ſoft; ſo as to leave a very ſmall aperture, in the lower part of this canal, ſufficient to diſcharge the Lead as it melts. Dry the whole by placing lighted coals around it.

When this apparatus is dry, put your mixed maſs of Copper and Lead into the upper veſſel: both in that, and in the other veſſel, light a very gentle fire of wood or charcoal, ſo as not to exceed the degree of heat neceſſary to melt Lead. In ſuch a degree of heat the Lead contained in the mixed maſs will melt, and you will ſee it run out of the upper veſſel into the lower; at the bottom of which it will unite into a Regulus. When in this degree of heat no more Lead flows, increaſe the fire a little, ſo as to make the veſſel moderately red.

When no more will run, collect the Lead contained in the lower veſſel. Melt it over again in an iron ladle, with a degree of fire ſufficient to make the ladle red; throw into it a little tallow or pitch, and while it burns keep ſtirring the metal, in order to reduce any part of it that may be calcined. Remove the pellicle or thin cruſt which will form on the ſurface; ſqueeze out all the Lead it contains, and then put it to the maſs of Copper left in the upper veſſel. Check the fire, and in the ſame manner take off a ſecond ſkin that will form on the ſurface of the Lead. Laſtly, when the metal is ready to fix, take off the ſkin that will then appear on it. The Lead remaining after this will be very pure, and free from all alloy of Copper.

With regard to the Copper itſelf, you will find it in the upper veſſel covered with a thin coat of Lead: and if the Lead mixed with it was in the proportion of a fourth or a fifth part only, and the fire applied was gentle and ſlow, it will retain nearly the ſame form after the operation that the mixed maſs had before.

OBSERVATIONS.

LEAD frequently remains mixed with Copper after the reduction of its ore, eſpecially if the ore was pyritoſe. Though Copper be a much more beautiful and more ductile metal than Lead, yet the latter by being alloyed with the former is rendered eager and brittle. This bad quality is eaſily diſcovered by the eye on breaking it: for the ſurface of the broken part appears all granulated; whereas when it is pure it is more evenly, and reſembles a congeries of ſolid angles. If the Lead be alloyed with a conſiderable quantity of Copper, its colour hath a yellowiſh caſt.

Conſidering the bad qualities which Copper communicates to Lead, it is neceſſary to ſeparate theſe two metals from each other. The method above laid down is the ſimpleſt and the beſt. It is founded on two properties belonging to Lead: the firſt is that of being much more fuſible than Copper; ſo that it will melt and run in a degree of heat that is not capable of making the Copper even red-hot, which yet is very far from being able to melt it: the ſecond is, that Lead, though it hath an affinity with Copper, and unites very perfectly therewith, yet is not able to diſſolve it without a greater heat than the degree barely neceſſary to fuſe Lead. Hence it comes that Lead may be melted in a Copper veſſel, provided no greater degree of heat be applied than that purpoſe requires. But when the Lead becomes ſo hot as to be red, fume, and boil, it inſtantly begins to diſſolve the Copper. For this reaſon, it is eſſential to the ſucceſs of our operation that a moderate degree of heat only be applied, and no greater than is requiſite to keep the Lead in fuſion.

Charcoal-duſt is made an ingredient in the compoſition of the veſſels uſed on this occaſion, in order to prevent the calcination of the Lead.

The iron plate, with which the entrance of the gutter within the upper veſſel is narrowed, ſerves to prevent the larger pieces of Copper, which the Lead may carry along with it, from paſſing through: it ſtops them, and allows the Lead to run off alone.

But as theſe parcels of Copper may entirely choak the paſſage, care muſt be taken, when any happen to be ſtopt, to remove them from the entrance of the gutter, and puſh them back into the middle of the veſſel. It is alſo neceſſary to obſerve whether or no the Lead fixes any where in the paſſage; and, if it does, the heat of that part muſt be increaſed, in order to melt it and make it run off.

Notwithſtanding all the precautions that can be taken, to hinder the melted Lead from carrying off any Copper with it, it is impoſſible to prevent this inconvenience entirely; and therefore the Lead is melted over again, in order to ſeparate the ſmall portion of Copper with which it is ſtill adulterated.

As Copper is much lighter than Lead, if theſe two metals happen to be ſo blended together that the Copper, without being in fuſion and diſſolved by the Lead, is only interpoſed between the parts of the melted Lead, ſo as to ſwim therein, it is then preciſely in the caſe of a ſolid body plunged into a fluid heavier than itſelf, and muſt riſe to the ſurface, like wood thrown into water. It is proper to burn ſome inflammable matter on this melted Lead, in order to reduce ſuch parts thereof as are conſtantly calcining on its ſurface while it is in fuſion; for without this precaution they would be taken off together with the Copper.

The Copper remaining after this ſeparation is, as we took notice before, ſtill mixed with a little Lead. If you deſire to ſeparate it entirely therefrom, you muſt put it into a cupel, and expoſe it under the muffle to ſuch a degree of fire as may convert all the Lead into litharge. This cannot be ſo done but that ſome of the Copper alſo will be ſcorified by the heat of the fire, and by the action of the Lead: but as there is a very great difference between the facility and readineſs with which theſe two metals calcine, the portion of Copper that is calcined, while the whole Lead is turning into litharge, is ſcarce worth conſidering.

The Lead, though carefully ſeparated from the Copper by the proceſs here delivered, is not yet abſolutely pure: ſometimes it is alloyed with Gold, and almoſt always contains ſome Silver. If you would free the Lead as much as poſſible from any mixture of theſe two metals, you muſt convert it into glaſs, ſeparate the remaining bead, and afterwards reduce this glaſs of Lead. But, as theſe two perfect metals are of no prejudice to the Lead, it is not uſual to ſeparate them from it, unleſs they be in a ſufficient proportion to defray the charge, and produce ſome profit beſides.

When we examine by the cupel the juſt proportion of Gold and Silver that an ore or a mixed metalline maſs will yield, we make a previous aſſay of the Lead to be employed in the operation, and afterwards, in our eſtimate, deduct a proper allowance for the quantity of fine metal due to the Lead made uſe of.

PROCESS III.

The Calcination of Lead.

TAKE what quantity of Lead you pleaſe; melt it in one or more unglazed earthen pans: a dark grey powder will be found on its ſurface. Keep ſtirring the metal inceſſantly till it be wholly converted into ſuch a powder, which is the *Calx of Lead.*

OBSERVATIONS.

As Lead is a very fuſible metal, and in that reſpect greatly reſembles Tin, moſt of the obſervations we made on the calcination of Tin may be applied here.

In the calcination of all metals, and particularly in this of Lead, there appears a ſingular phenomenon which is not eaſily accounted for. It is this: though theſe matters loſe a great deal of their ſubſtance, either by the diſſipation of their phlogiſton, or becauſe ſome of the metal, perhaps, exhales in vapours, yet when the calcination is over their calces are found to be increaſed in weight, and this increaſe is very conſiderable. An hundred pounds of Lead, for example, converted into Minium, which is nothing but a calx of Lead brought to a red colour by continuing the calcination, are found to gain ten pounds weight; ſo that for an hundred pounds of Lead we have one hundred and ten pounds of Minium: a prodigious and almoſt incredible augmentation, if it be conſidered that, far from adding any thing to the Lead, we have on the contrary diſſipated part of it.

To account for this phenomenon Natural Philoſophers and Chymiſts have invented ſeveral ingenious hypotheſes, but none of them entirely ſatisfactory. As we have no eſtabliſhed theory to proceed upon, we ſhall not undertake to explain this extroardinary fact.

PROCESS IV.

To prepare Glaſs of Lead.

TAKE two parts of Litharge, and one part of pure cryſtalline Sand; mingle them together as exactly as poſſible, adding a little Nitre and Sea-ſalt: put this mixture into a crucible of the moſt ſolid and moſt compact earth. Shut the crucible with a cover that may perfectly cloſe it.

Set the crucible thus prepared in a melting furnace; fill the furnace with coals; light the fire gradually, ſo that the whole may be ſlowly heated: then raiſe the fire ſo as to make the crucible very red, and bring the matter it contains into fuſion; keep it thus melted for a quarter of an hour.

Then take the crucible out of the furnace, and break it: in the bottom thereof you will moſt commonly find a ſmall button of Lead, and over it a tranſparent Glaſs, of a yellow colour nearly reſembling that of amber. Separate this Glaſs from the little button of metal, and from the ſaline matters which you will find above it.

OBSERVATIONS.

Pure Lead, being expoſed to a ſtrong fire without any additament, turns to Litharge; which is a ſcaly ſort of ſubſtance, more or leſs yellowiſh, ſhining, and ſoft to the touch. This is the firſt advance to the Vitrification of Lead. The large refineries of Gold and Silver by the means of Lead furniſh a great quantity of this material. It is ſometimes whitiſh, and is then called *Litharge of Silver;* ſometimes yellow, and then bears the name of *Litharge of Gold.* The difference of its colour depends on the degree of fire it hath undergone, and on the metalline ſubſtances vitrified with it.

Litharge alone is very fuſible, and being expoſed to the fire is eaſily converted into glaſs: but this Glaſs of Lead, made without additament, is ſo active, ſo penetrating, and ſo apt to ſwell, that it can ſcarcely be made uſe of when pure. We are obliged in ſome ſort to clog it, by uniting it with ſome vitrifiable matter that is not ſo ſubtile, ſuch as ſand; and it is for this reaſon, not to render the mixture more fuſible, that we have directed the addition of one third part of Sand to two thirds of Litharge.

The Nitre and Sea-ſalt, preſcribed as ingredients in the mixture, are deſigned to procure an equal fuſion of the whole. For, as the ſand is lighter and leſs fuſible than the Litharge, it will partly riſe towards the upper part of the crucible when that matter firſt begins to flow; in conſequence whereof the contents of the upper part will be much more difficult to melt, and form a Glaſs much more compact than that below: but the Nitre and Sea-ſalt poſſeſſing the upper part of the crucible, becauſe they are ſtill lighter than the Sand, and being in their own nature very efficacious fluxes, on account of their great fuſibility, they quickly bring about the fuſion of thoſe particles of ſand, which, having eſcaped the action of the Litharge, may have riſen unvitrified to its ſurface.

The moſt difficult thing to procure, and yet the moſt neceſſary to the ſucceſs of this operation, is a crucible of earth ſo firm and compact as not to be penetrated by the Glaſs of Lead, which corrodes and makes its way through every thing.

The precaution of chuſing a crucible, that ſhall contain a good deal more than the matter to be vitrified, is a neceſſary one, becauſe Litharge and Glaſs of Lead are very apt to ſwell.

The rule to keep the crucible cloſe ſhut is alſo indiſpenſably neceſſary, to prevent any bit of charcoal, or other inflammable matter, from falling into it: for when this happens it occaſions a reduction of the Lead, which is always attended with a ſort of effervеſcence, and ſuch a conſiderable heaving, that commonly moſt of the mixture runs over the crucible. For the ſame reaſon it is very proper, before you expoſe the mixture to the fire, to examine whether or no it contains any matter capable of furniſhing a phlogiſton during the operation; and if it does, to remove that matter with great care.

The little button of Lead, found at the bottom of the crucible after the operation, comes from a ſmall portion of Lead that is commonly left in Litharge, unleſs you prepare it carefully yourſelf, and do not take it from the fire till you are ſure of having deſtroyed all the Lead. Beſides, this ſmall portion of Lead can be of no prejudice to the operation, becauſe it cannot communicate its phlogiſton to the reſt of the matter.

The revivifying of Litharge, of the Calx, and of the Glaſs of Lead, may be obtained by the ſame proceſſes as the reduction of its ore.

PROCESS V.

Lead diſſolved by the Nitrous Acid.

PUT into a matraſs ſome *aqua fortis* precipitated like that uſed to diſſolve Silver; weaken it by mixing therewith an equal quantity of common water; ſet the matraſs in a hot ſand-bath; throw into it, little by little, ſmall bits of Lead, till you ſee that no more will diſſolve. *Aqua fortis* thus lowered will diſſolve about a fourth of its weight of Lead.

There is gradually formed upon the Lead, as it diſſolves, firſt a grey powder, and afterwards a white cruſt, which at laſt hinder the ſolvent from acting on the remaining part of the metal; and therefore the liquor ſhould be made to boil, and the veſſel ſhould be ſhaken to remove thoſe impediments, by which means all the Lead will be diſſolved.

OBSERVATIONS.

LEAD very much reſembles Silver, with reſpect to the phenomena which attend its diſſolution in Acids. For example,

ample, the Nitrous Acid muſt be very pure and uncontaminated with the Vitriolic or Marine Acid, to qualify it for keeping the Lead in ſolution: for, if it be mixed with either the one or the other of theſe Acids, the Lead will precipitate in the form of a white powder as faſt as it diſſolves; which is juſt the caſe with Silver.

If the Vitriolic Acid be mixed with the Nitrous, the precipitate will be a combination of the Vitriolic Acid with Lead; that is, a Neutral Metallic Salt, or Vitriol of Lead. If the Acid of Sea-ſalt be mixed therewith, the precipitate will be a *Plumbum corneum;* that is, a Metallic Salt reſembling the *Luna cornea.*

When all the Lead is diſſolved as above deſcribed, the liquor appears milky. If it be kept warm over the fire till little cryſtals begin to appear on its ſurface, and afterwards left to ſtand quiet, in a certain time there will be found at the bottom a greyiſh powder, which being tried on Gold is Mercurial enough to whiten it. Little globules of Quick-ſilver are even diſcernible in it.

We owe this obſervation, together with this manner of proving the exiſtence of Mercury in Lead, and of procuring it from thence, to M. Groſſe, who hath given an account of his proceſs in the Memoirs of the Academy of Sciences, from whence we have copied the deſcription of the operation in hand.

The ſolution being quickly poured off by inclination from the grey mercurial precipitate is ſtill milky, and depoſites another white ſediment. When this ſecond precipitate falls the liquor becomes clear and limpid, and is then of a fine yellow colour, like a ſolution of Gold. On this gold-coloured ſolution, and on the two precipitates above-mentioned, M. Groſſe made ſeveral obſervations, the chief of which we ſhall here inſert.

The yellow liquor affects the tongue at firſt with a taſte of ſweetneſs; but afterwards vellicates it very ſmartly, and leaves on it a ſtrong ſenſation of acrimony, which continues for a long time.

Alkalis precipitate the Lead ſuſpended in this liquor, juſt as they do all other metals diſſolved by Acids; and this precipitate of Lead is white.

Sea-ſalt, or Spirit of Salt, ſeparates the Lead from its ſolvent, and precipitates it, as we obſerved before, into a *Plumbum corneum:* but this precipitate differs from the *Luna cornea,* as being very ſoluble in water; whereas the *Luna cornea* will not diſſolve in it at all; or at leaſt diſſolves therein with great difficulty, and in a very ſmall quantity. This *Plumbum corneum* diſſolved in water is again precipitated by the Vitriolic Acid. M. Groſſe obſerves, that this forms an exception to the eighth column of Mr. Geoffroy's Table of Affinities; in which the Acid of Sea-ſalt is marked as having a greater affinity than any other Acid with Metallic ſubſtances.

Our ſolution of Lead is alſo precipitated in a white powder by ſeveral Neutral Salts; ſuch as Vitriolated Tartar, Alum, and common Vitriol. It is by the means of double affinities that theſe Neutral Salts effect this precipitation.

Even pure water alone is capable of precipitating the Lead of our ſolution, by weakening the Acid, and thereby diſabling it from keeping the metal ſuſpended.

Laſtly, as all the ſolutions of metals in Acids are nothing but Neutral Metallic Salts in a fluid form, ſo if the ſolution of Lead be evaporated over the fire, it will ſhoot into very beautiful cryſtals, about the bigneſs of hemp-ſeed, ſhaped like regular pyramids having ſquare baſes. Theſe cryſtals are yellowiſh, and have a ſweet ſaccharine taſte: but what is moſt ſingular in them is, that, as they conſiſt of the Nitrous Acid combined with Lead, which manifeſtly contains a great deal of phlogiſton, they conſtitute a Nitrous Metallic Salt, which has the property of deflagrating in a crucible, without the addition of any other inflammable matter. It is extremely hard to diſſolve this Salt in water.

The grey mercurial precipitate which whitens Gold, and in which little globules of running Mercury are perceivable, is far from being pure Mercury. This metallic ſubſtance makes but a ſmall part thereof: for it is an aſſemblage, 1. of little cryſtals of the ſame nature with thoſe afforded by the evaporated ſolution; 2. of a portion of the white matter, or powder, which renders the ſolution milky; 3. of a grey powder, which M. Groſſe conſiders as the only mercurial part; 4. and laſtly, of little particles of Lead that have eſcaped the action of the ſolvent; eſpecially if a little more Lead than the Acid is capable of diſſolving were added with a view to ſaturate it entirely, as in the preſent proceſs.

By means of motion and heat the ſmall parcels of Mercury may be amalgamated with the Lead.

That Mercury ſhould be found entire and in globules in the Spirit of Nitre, which very eaſily diſſolves that metallic ſubſtance, will not be ſurprizing to thoſe who reflect that, in the preſent caſe, the Acid is ſaturated with Lead, with which it has a greater affinity than with Mercury; as appears by M. Geoffroy's Table of Affinities, where, in the column that hath the Nitrous Acid at top, Lead is placed above Mercury. Agreeably to this, if Lead be preſented to a ſolution of Mercury in Spirit of Nitre, the Lead will be diſſolved, and as the diſſolution thereof advances the Mercury will precipitate.

Hence it appears that, in order to find any Mercury in the ſpontaneous precipitate of Lead diſſolved by the Nitrous Acid, it is neceſſary that the Acid be entirely ſaturated with Lead; or elſe that portion of the Acid which remains unſaturated will diſſolve the Mercury.

With regard to the white powder that renders the ſolution milky, and afterwards precipitates, it is nothing but a portion of the Lead, which, not being intimately united with the Acid, falls in part of its own accord. It is a ſort of calx of Lead, which being expoſed to the fire becomes partly glaſs, and partly Lead, becauſe it ſtill retains ſome of its phlogiſton.

CHAP. VII.

Of MERCURY.

PROCESS I.

To extract Mercury from its Ore, or to revivify it from Cinabar.

PULVERIZE the Cinabar from which you would extract the Mercury; with this powder mix an equal part of clean iron filings; put the mixture into a retort of glaſs or iron, leaving at leaſt one third part thereof empty. Set the retort thus prepared in a ſand-bath, ſo that its body may be quite buried in the ſand, and its neck decline conſiderably downwards: fit on a receiver half filled with water, and let the noſe of the retort enter about half an inch into the water.

Heat the veſſels ſo as to make the retort moderately red. The Mercury will riſe in vapours, which will condenſe into little drops, and fall into the water in the receiver. When you ſee that nothing more comes over with this degree of heat, increaſe it, in order to raiſe what Mercury may ſtill be left. When all the Mercury is thus brought over, take off the receiver, pour out the water contained in it, and collect the Mercury.

OBSERVATIONS.

MERCURY is never mineralized in the bowels of the earth by any thing but Sulphur; with which it forms a compound of a browniſh red colour, known by the name of *Cinabar*.

Sometimes it is only mixed with earthy and ſtony matters that contain no Sulphur; but, as this metallic ſubſtance is never deſtitute of its phlogiſton, it then has its metalline form and properties. When it is found in this condition, nothing is more eaſy than to ſeparate it from thoſe heterogeneous matters. For that purpoſe no more is requiſite than to diſtil the whole with a fire ſtrong enough to raiſe the Mercury in vapours. This mineral is volatile; the earthy and ſtony matters are fixed; and a certain degree of heat will effect a complete ſeparation of what is volatile from what is fixed.

This is not the caſe when Mercury is combined with Sulphur: for this latter mineral is volatile as well as Mercury; and the compound reſulting from the union of them both is alſo volatile: ſo that if Cinabar were expoſed to the fire in cloſe veſſels, as it muſt be to ſave the Mercury, it would be ſublimed in ſubſtance, without being decompoſed at all.

In order therefore to ſeparate theſe two ſubſtances from each other, we muſt have recourſe to the interpoſition of ſome third, which hath a greater affinity with one of them than the other hath, and no affinity with that other.

Iron hath all the conditions requiſite for this purpoſe; ſeeing it hath, as may be ſeen in the Table, a much greater affinity with Sulphur than Mercury hath, and is incapable of contracting any union with Mercury.

Iron, however, is not the only ſubſtance that may be employed on this occaſion: Fixed Alkalis, Abſorbent earths, Copper, Lead, Silver, Regulus of Antimony, have all, as well as Iron, a greater affinity than Mercury with Sulphur. Nay, ſeveral of theſe ſubſtances, namely, the ſaline and earthy Alkalis, as well as Regulus of Antimony, cannot contract any union with Mercury: the reſt, to wit, Copper, Lead, and Silver, are indeed capable of amalgamating with Mercury; but then the union which theſe metals contract with the Sulphur prevents it; and even though they ſhould unite with this metallic ſubſtance, the degree of heat to which the whole mixture is expoſed would ſoon carry up the Mercury, and ſeparate it with eaſe from thoſe fixed ſubſtances.

In this diſtillation the ſame cautions muſt be obſerved as in all others: that is, the veſſels muſt be ſlowly heated, eſpecially if a glaſs retort be uſed; the fire muſt be raiſed by degrees, and a much ſtronger one applied at laſt than at firſt. This operation particularly requires a very ſtrong degree of fire, when there is but a ſmall quantity of Mercury left.

After the operation there remains in the retort a compound of Iron and Sulphur, which may eaſily be converted into a *crocus*, by calcining it and burning away the Sulphur.

If a Fixed Alkali be employed, a Liver of Sulphur will be found in the retort after the diſtillation.

If the Cinabar from which you extract the Mercury be good, you will generally obtain ſeven eighths of its weight in Quick-ſilver.

In the preſent operation it is not neceſſary to lute on the receiver, becauſe the water, in which the noſe of the retort is plunged, is ſufficient to fix the Mercurial vapours. In caſe the Cinabar, from which you intend to ſeparate the Mercury, be mixed with a great quantity of heterogeneous, but fixed, matters, ſuch as earths, ſtones, &c. it may be ſeparated from them by ſubliming it with a proper degree of heat, becauſe it is volatile.

The vapours of Mercury are prejudicial, and may excite a ſalivation, tremors, and palſies; they ſhould therefore be always avoided by ſuch as work on this mineral.

The oldeſt and richeſt mine of Mercury is that of Almaden in Spain. It is a ſingular property of that mine that, though the Mercury found in it is combined with Sulphur, and in the form of Cinabar, yet no additament is required to procure the ſeparation of theſe two; the earthy and ſtony matter, with which the particles of the ore are incorporated, being itſelf an excellent abſorbent of Sulphur.

In the Quick-ſilver works carried on at this mine they make no uſe of retorts. They place lumps of the ore on an iron grate, which ſtands immedietely over the furnace. The furnaces which ſerve for this operation are cloſed at the top by a ſort of dome, behind which ſtands the ſhaft of a chimney that communicates with the fire-place, and gives vent to the ſmoke. Theſe furnaces have in their fore-ſide ſixteen apertures, to each of which is luted an aludel in a horizontal poſition, communicating with a long row of other aludels placed likewiſe in an horizontal direction; which aludels ſo connected together form one long pipe or canal, the further end whereof opens into a chamber deſtined to receive and condenſe all the mercurial vapours. Theſe rows of aludels are ſupported from end to end by a terraſs, which runs from the body of the building, wherein the furnaces are erected, to that where the chambers are built that perform the office of receivers.

This is a very ingenious contrivance and ſaves much labour, expence, and trouble, that would be unavoidable if retorts were employed.

That part of the furnace which contains the lumps of ore, ſerves for the body of the retort; the row of aludels for its neck; and the little chambers in which theſe canals terminate are actual receivers. The terraſs of communication, which reaches from the one building to the other, is formed of two inclined planes, the lower edges of which, meeting in the middle of the terraſs, riſe from thence inſenſibly; the one quite to the building where the furnaces are, and the other to that which forms the recipient chambers. By this means, when any Mercury eſcapes through the joints of the aludels, it naturally runs down along theſe inclined planes, and ſo is collected in the middle of the terraſs, where the inferior ſides of the planes meeting together form a ſort of canal, out of which it is eaſily taken up.

The celebrated M. de Juſſieu having viewed the whole himſelf, in a journey he made to this mine, furniſhed us with this deſcription of the work.

PROCESS II.

To give Mercury, by the action of Fire, the appearance of a Metalline Calx.

PUT Mercury into ſeveral little glaſs matraſſes with long and narrow necks. Stop the matraſſes with a little paper, to prevent any dirt from falling into them. Set them all in one ſand-bath, ſo that they may be ſurrounded with ſand as high as two thirds of their length. Apply the ſtrongeſt degree of heat that Mercury can bear without ſubliming: continue this heat without interruption, till all the Mercury be turned to a red powder. The operation laſts about three months.

OBSER-

OBSERVATIONS.

MERCURY treated according to the proceſs here delivered hath all the appearance of a metalline calx, but it hath no more: for, if it be expoſed to a pretty ſtrong degree of fire, it ſublimes, and is wholly reduced to running Mercury, without the addition of any other inflammable matter; which proves that during this long calcination it loſt none of its phlogiſton.

The volatile nature of Mercury, which permits it not to bear a heat of any ſtrength without ſubliming, prevents our examining all the effects that fire is capable of producing on it. Yet there is reaſon to believe that, as this metallic ſubſtance reſembles the perfect metals in its weight, its ſplendour, and a brilliancy which reſiſts all the impreſſions of the air without alteration, it would like them be unchangeable by the greateſt force of fire, if it were fixed enough to bear it.

In order to give Mercury the form of a metalline calx, it muſt neceſſarily be expoſed for about three months together, to the utmoſt heat it can bear without ſubliming, as is above directed. Boerhaave kept it digeſting in a leſs heat for fifteen years ſucceſſively, both in open and in cloſe veſſels, without obſerving it to ſuffer the leaſt change; except that there was formed upon its ſurface a ſmall quantity of a black powder, which was reduced to running Mercury by trituration alone.

Mercury thus converted to a red powder is known in chymiſtry and medicine by the name of *Mercury precipitated per ſe:* a title proper enough, as it is actually reduced to the form of a precipitate, and that without any additament; but very improper on the other hand, conſidering, that in reality this Mercury is not a precipitate, as not having been ſeparated from any menſtruum in which it was diſſolved.

PROCESS III.

To diſſolve Mercury in the Vitriolic Acid. Turbith Mineral.

PUT Mercury into a glaſs retort, and pour on it thrice its weight of good Oil of Vitriol. Set the retort in a ſand bath; fit on a recipient; warm the bath by degrees till the liquor juſt ſimmer. With this heat the Mercury will begin to diſſolve. Continue the fire in this degree till all the Mercury be diſſolved.

OBSERVATIONS.

THE Vitriolic Acid diſſolves Mercury pretty well: but for this purpoſe the Acid muſt be very hot, or even boil; and then too it is a very long time before the diſſolution is completed. We have directed the operation to be performed in a retort; becauſe this ſolution is uſually employed to make another preparation called *Turbith Mineral*, which requires that as much as poſſible of the Acid ſolvent be abſtracted by diſtillation. Having therefore diſſolved your Mercury in the Vitriolic Acid, if you will now prepare the Turbith, you muſt, by continuing to heat the retort, drive over all the liquor into the receiver, and diſtil till nothing remains but a white powdery matter: then break the retort; pulverize its contents in a glaſs mortar, and thereon pour common water, which will immediately turn the white matter of a lemon-colour; waſh this yellow matter in five or ſix warm waters, and it will be what is called in medicine *Turbith Mineral;* that is, a combination of the Vitriolic Acid with Mercury, five or ſix grains whereof is a violent purgative, and alſo an emetic; qualities which it poſſeſſes in common with the Vegetable Turbith, whoſe name it hath therefore taken.

There riſes out of the retort, both while the Mercury is diſſolving, and while the ſolvent is abſtracting, a weak Spirit of Vitriol; becauſe a great part of the Acid remains united with the Quick-ſilver, which at laſt appears in the form of a white powder: ſo that, if you do not incline to ſave the Acid which riſes on this occaſion, you may, inſtead of drawing off the liquor in a retort, evaporate it in a glaſs baſon ſet on a ſand-bath, which will be much ſooner done.

It is very remarkable that, on this occaſion, the Mercury may be expoſed, without any danger of ſubliming, to a much greater heat than it is capable of bearing when not combined with the Vitriolic Acid; which ſhews that this Acid hath the property of fixing Mercury to a certain degree.

The white matter, that remains after the evaporation of the fluid, is one of the moſt violent corroſives, and would prove an actual poiſon if taken internally. By waſhing it ſeveral times in warm water it is freed from a great deal of its Acid, and ſo conſiderably ſweetened. The proof is this;

if the water uſed in waſhing the Turbith be evaporated, there remains after the evaporation a matter in form of a Salt, that being ſet in a cellar runs into a liquor called *Oil of Mercury*, which is a powerful corroſive. Several authors further direct Spirit of Wine to be burnt on the Turbith, to ſweeten it ſtill more.

If, inſtead of waſhing the white matter that remains after the moiſture is drawn off, freſh Oil of Vitriol be poured on it, and then abſtracted as before; this treatment being repeated two or three times, there will at laſt remain in the retort a matter having the appearance of an oil, which reſiſts the action of the fire, and cannot be deſiccated: qualities which are owing to the great quantity of Acid particles thus united with the Mercury. This Oil of Mercury is one of the moſt violent corroſives. The Mercury may be ſeparated therefrom, by precipitating it with an Alkali, or a metallic ſubſtance that hath more affinity than Mercury with the Vitriolic Acid: Iron, for inſtance, may be employed in this precipitation. Mercury thus ſeparated from the Vitriolic Acid need only be diſtilled to recover the form of Quickſilver.

PROCESS IV.

To combine Mercury with Sulphur. Æthiops Mineral.

MIX a dram of Sulphur with three drams of Quickſilver, by triturating the whole in a glaſs mortar with a glaſs peſtle. By degrees, as you triturate, the Mercury will diſappear, and the matter will acquire a black colour. Continue the triture till you cannot perceive the leaſt particle of running Mercury. The black matter you will then have in the mortar is known in medicine by the name of *Æthiops Mineral.* An Æthiops may alſo be made by fire in the following manner.

In a ſhallow unglazed earthen pan melt one part of flowers of Sulphur: add three parts of running Mercury, making it fall into the pan in the form of ſmall rain, by ſqueezing it through chamoy leather. Keep ſtirring the mixture with the ſhank of a tobacco-pipe all the while the Mercury is falling: you will ſee the matter grow thick and acquire a black colour. When the whole is thoroughly mixed, ſet fire to it with a match, and let as much of the Sulphur burn away as will flame.

OBSER-

OBSERVATIONS.

MERCURY and Sulphur unite together with great eaſe; cold triture alone is ſufficient to join them. By this means the Mercury is reduced into exceeding ſmall atoms, and combines ſo perfectly with the Sulphur that the leaſt veſtige thereof is not to be ſeen.

Sulphur is not the only matter which being rubbed with Mercury will deſtroy its form and fluidity: all fat ſubſtances that have any degree of conſiſtence, ſuch as the fat of animals, balſams, and reſins, are capable of producing the ſame effect. This metallic ſubſtance, being triturated for ſome time in a mortar with theſe matters, becomes at laſt inviſible, and communicates to them a black colour. When thus divided by the interpoſition of heterogeneous particles, it is ſaid to be *Killed*. But Mercury doth not contract ſuch an intimate union with theſe other matters as it doth with Sulphur.

The Æthiops prepared by fuſion is a more perfect and accurate combination of Mercury and Sulphur than the other: for, the quantity of Sulphur directed to be uſed in making it being much greater than is abſolutely neceſſary to fix the Mercury, the redundant Sulphur is deſtroyed by burning, and none left but what is moſt intimately united with the Mercury; and hindered by the union it hath contracted with that metallic ſubſtance from being ſo eaſily conſumed. The Æthiops therefore, which is prepared by fuſion and burning the Sulphur, contains a much greater proportion of Mercury than that which is made by ſimple triture; ſo that in Medicine it ought to be preſcribed in different caſes, and in ſmaller doſes.

If no more Sulphur than is juſt neceſſary to kill the Mercury be added to it at firſt, it will be difficult to obtain a perfect mixture; becauſe that quantity is very ſmall: it is better, therefore, to employ at once the quantity above directed.

PROCESS V.

To ſublime the Combination of Mercury and Sulphur into Cinabar.

GRIND to powder Æthiops mineral prepared by fire. Put it into a cucurbit; fit thereto a head; place it in a ſand-bath, and begin with applying ſuch a degree of heat as is requiſite to ſublime Sulphur. A black matter will riſe, and adhere to the ſides of the veſſel. When nothing more will riſe with this degree of heat, raiſe the fire ſo as to make the ſand and the bottom of the cucurbit red; and then the remaining matter will ſublime in the form of a browniſh red maſs, which is true *Cinabar*.

OBSERVATIONS.

ÆTHIOPS Mineral requires nothing but ſublimation to become true Cinabar, like that found in Quick-ſilver mines: but our Æthiops contains ſtill more Sulphur than ought to be in the compoſition of Cinabar; for which reaſon we have directed the degree of fire applied at firſt to be no greater than that which is capable of ſubliming Sulphur. As Cinabar, though conſiſting of Mercury and Sulphur, is yet much leſs volatile than either of theſe ſubſtances alone; which probably ariſes from the Vitriolic Acid contained in the Sulphur; therefore, if there be any redundant Sulphur in the Æthiops, which hath not contracted an intimate union with the Mercury, it will ſublime by itſelf in this firſt degree of heat. Some mercurial particles alſo will riſe with it, and give it a black colour.

Cinabar contains no more Sulphur than about a ſixth or ſeventh part of its weight: ſo that, inſtead of employing the common Æthiops to make it, it would be better to prepare one on purpoſe that ſhould contain much leſs Sulphur; becauſe too much Sulphur prevents the ſucceſs of the operation by blackening the Sublimate. Indeed in whatever manner you go about it, the Cinabar always appears black at firſt: but when it is well prepared, and contains no more than its due proportion of Sulphur, the blackneſs is only external. This black coat therefore may be taken off; and then the internal part will appear of a fine red, and, if ſublimed a ſecond time, will be very beautiful.

As artificial Cinabar hath the ſame properties with the native, it may be decompoſed by the ſame means: ſo that, if you want to extract the Mercury out of it, recourſe muſt be had to the proceſs above delivered for working on Cinabar ores.

PROCESS VI.

To diſſolve Mercury in the Nitrous Acid. Sundry Mercurial Precipitates.

PUT into a matraſs the quantity of Mercury you intend to diſſolve: pour on it an equal quantity of good Spirit of Nitre, and ſet the matraſs in a ſand-bath moderately heated. The Mercury will diſſolve with the phenomena that uſually attend the diſſolutions of metals in this Acid. When the diſſolution is completed let the liquor cool. You will know that the Acid is perfectly ſaturated, if there remain at the bottom of the veſſel, notwithſtanding the heat, a little globule of Mercury that will not diſſolve.

OBSERVATIONS.

MERCURY diſſolves in the Nitrous Acid with much more facility, and in much greater quantity, than in the Vitriolic; ſo that it is not neceſſary, on this occaſion, to make the liquor boil. This ſolution when cold yields cryſtals, which are a Nitrous Mercurial Salt. If you deſire to have a clear limpid ſolution of Mercury, you muſt employ an *aqua fortis* that is not tainted with the Vitriolic or Marine Acid: for, the affinity of theſe two Acids with Mercury being greater than that of the Nitrous Acid, they precipitate it in the form of a white powder, when they are mixed with the ſolvent.

Mercury thus precipitated in a white powder, out of a ſolution thereof in the Spirit of Nitre, is uſed in Medicine. To obtain this precipitate, which is known by the name of the *White Precipitate*, Sea-ſalt diſſolved in water together with a little Sal Ammoniac is uſed; and the precipitate is waſhed ſeveral times in pure water, without which precaution it would be corroſive, on account of the great quantity of the Marine Acid which it would contain.

The preparation known by the name of *Red Precipitate* is alſo obtained from our ſolution of Mercury in Spirit of

Nitre. It is made by abſtracting all the moiſture of the ſolution, either by diſtillation in a retort, or by evaporation in a glaſs baſon ſet on a ſand-bath. When it begins to grow dry it appears like a white ponderous maſs. Then the fire is made ſtrong enough to drive off almoſt all the Nitrous Acid, which, being now concentrated, riſes in the form of red vapours. If theſe vapours be catched in a receiver, they condenſe into a liquor, which is a very ſtrong and vaſtly ſmoking Spirit of Nitre.

By degrees, as the Nitrous Acid is forced up by the fire, the mercurial maſs loſes its white colour, and becomes firſt yellow, and at laſt very red. When it is become entirely of this laſt colour the operation is finiſhed. The red maſs remaining is a Mercury that contains but very little Acid, in compariſon of what it did while it was white: and indeed the firſt white maſs is ſuch a violent corroſive, that it cannot be uſed in Medicine; whereas, when it is become red, it makes an excellent eſcharotic, which thoſe who know how to uſe it properly apply with very great ſucceſs, particularly to venereal ulcers.

This preparation is very improperly called a *Precipitate*: for the Mercury is not ſeparated from the Spirit of Nitre by the interpoſition of any other ſubſtance, but only by evaporating the Acid. It is alſo called *Arcanum Corallinum.*

It muſt be obſerved that Mercury, by its union with the Nitrous Acid, acquires a certain degree of fixity: for the red precipitate is capable of ſuſtaining, without being volatilized, a ſtronger degree of heat than pure Mercury can; which, as we obſerved before, is the property of Turbith Mineral alſo.

PROCESS VII.

To combine Mercury with the Acid of Sea-ſalt. Corroſive Sublimate.

EVAPORATE a ſolution of Mercury in the Nitrous Acid till there remain only a white powder, as mentioned in our obſervations on the preceding proceſs. With this powder mix as much Green Vitriol calcined to whiteneſs, and as much decrepitated Sea-ſalt, as there was Mercury in the ſolution. Triturate the whole carefully in a glaſs mortar. Put this mixture into a matraſs, ſo that two thirds thereof may remain empty, having firſt cut off the neck to half its length: or inſtead thereof you may uſe an apothecary's phial. Set your veſſel in a ſand-bath, and put ſand round it as high as the contents can reach. Apply a moderate fire at firſt, and raiſe it by ſlow degrees. Vapours will begin to aſcend. Continue the fire in the ſame degree till they ceaſe. Then ſtop the mouth of the veſſel with paper, and increaſe the fire till the bottom of the ſand-bath be red-hot. With this degree of heat a Sublimate will riſe, and adhere to the inſide and upper part of the veſſel, in the form of white, ſemi-tranſparent cryſtals. Keep up the fire to the ſame degree till nothing more will ſublime. Then let the veſſel cool; break it, and take out what is ſublimed, which is *Corroſive Sublimate.*

OBSERVATIONS.

In this operation the mineral Acids act, and are acted upon, in a remarkable manner. Every one of the three is at firſt neutralized, or united with a different baſis; the Vitriolic being combined with Iron; the Nitrous with Mercury, forming therewith a Nitrous Mercurial Salt; and the Marine with its natural Alkaline baſis. The Vitriolic and Nitrous Acids, which are united with metalline ſubſtances, being both ſtronger than the Acid of Sea-ſalt, ſtrive to expel it from its baſis, in order to combine with it themſelves; but the Vitriolic Acid, being the ſtrongeſt of the two, would take ſole poſſeſſion of this baſis excluſive of the Nitrous, which would continue united with the Mercury, if the Marine Acid had not a greater affinity than the Nitrous with this metallic ſubſtance. This Acid therefore being expelled from its baſis by the Vitriolic Acid, and ſo ſet at liberty, muſt unite with the Mercury, and ſeparate the Nitrous Acid from it; which now hath no reſource but to unite with the Iron deſerted by the Vitriolic Acid. But as all theſe changes are brought about by the means of a conſiderable heat, and as the Nitrous Acid hath not a very firm connection with the Iron, it is driven off by the force of the fire; and this it is which we ſee riſe in vapours during the operation. It alſo carries off with it ſome parts of the other two Acids, but in a very ſmall quantity. After the operation therefore there remains, 1. A combination of the Vitriolic Acid with the baſis of Sea-ſalt; that is, a Glauber's Salt: 2. A red martial earth, being that which was the baſis of the Vitriol: theſe two ſubſtances are blended together, and remain at the bottom of the veſſel becauſe of their fixity: 3. A combination

tion of the Marine Acid with Mercury; both of which being volatile, they aſcend together into the upper part of the veſſel, and there form a Corroſive Sublimate.

If we reflect on this proceſs with attention, and recollect diſtinctly the affinities of the different ſubſtances employed in it, we ſhall perceive that it is not neceſſary to make uſe of all thoſe matters, and that the operation would ſucceed though ſeveral of them were left out.

Firſt, the Nitrous Acid may be omitted; ſince, as hath been ſhewn, it is not an ingredient in the Sublimate, but is diſſipated in vapours during the operation. From an accurate mixture therefore of Vitriol, Sea-ſalt, and Mercury, a Corroſive Sublimate muſt be obtained: for as the Acid of the Vitriol will diſengage the Acid of Sea-ſalt, the latter will be at liberty to combine with the Mercury, and ſo form the compound we are in queſt of.

Secondly, if we make uſe of Mercury diſſolved by the Nitrous Acid, we may omit the Vitriol; becauſe the Nitrous Acid having a greater affinity than the Marine Acid itſelf with the baſis of Sea-ſalt, and the Acid of Sea-ſalt having a greater affinity than the Nitrous Acid with Mercury, theſe two Acids will naturally make an exchange of the baſes with which they are united: the Nitrous will lay hold on the baſis of Sea-ſalt, and form a quadrangular Nitre, while the Marine Acid will join the Mercury, and with it form a Corroſive Sublimate.

Thirdly, inſtead of Sea-ſalt its Acid only may be employed; which being mixed with the ſolution of Mercury in the Spirit of Nitre, will, by virtue of its greater affinity with that metallic ſubſtance, ſeparate it from the Nitrous Acid, unite with it, and form a white mercurial precipitate, which need only be ſublimed to become the combination required.

Fourthly, inſtead of Mercury diſſolved in the Nitrous Acid, Mercury diſſolved by the Vitriolic Acid, or Turbith, may be uſed; only mixing Sea-ſalt therewith: for theſe two ſaline ſubſtances will mutually decompound each other, by virtue of the affinities of their Acids, and for the ſame reaſons that Sea-ſalt and the Mercurial Nitrous Salt decompound each other. The Vitriolic Acid quits the Mercury with which it is combined, to unite with the baſis of the Sea-ſalt; and the Acid of this Salt being expelled by the Vitriolic, combines with the Mercury, and conſequently forms our Corroſive Sublimate. In this caſe a Glauber's Salt remains after the ſublimation.

Theſe ſeveral methods of preparing Corroſive Sublimate are never uſed, becauſe each of them is attended with ſome inconvenience; ſuch as requiring too long triture, yielding a Sublimate leſs corroſive than it ſhould be, or a ſmaller quantity of it. We muſt, however, except the laſt; which was invented by the late Mr. Boulduc, of the Academy of Sciences, who found none of theſe inconveniencies attending it *.

Corroſive Sublimate may alſo be made only by mixing Mercury with Sea-ſalt, without any additament. This may appear ſurprizing when we conſider that, as Acids have a greater affinity with Alkalis than with metallic ſubſtances, the Acid of Sea-ſalt ought not to quit its baſis, which is Alkaline, to unite with Mercury.

In order to explain this phenomenon it muſt be remembered that Sea-ſalt, when expoſed to the fire without additament, ſuffers a little of its Acid to eſcape. Now this portion of the Marine Acid unites with the Mercury, and forms a Corroſive Sublimate. Moreover, as there is a pretty ſtrong affinity between the Marine Acid and Mercury, this may help to detach from the Sea-ſalt a greater quantity of Acid than it would otherwiſe part with. Nevertheleſs, the quantity of Sublimate obtained by this means is not conſiderable, nor is it very corroſive.

On this occaſion we muſt alſo mention another combination of the Marine Acid with Mercury; which is made by mixing that metallic ſubſtance perfectly with Sal Ammoniac, by the means of triture. Mercury, like all other metals except Gold, poſſeſſes the property of decompounding Sal Ammoniac, ſeparating the volatile Alkali which ſerves it for a baſis, and combining, by the help of a very gentle heat, with its Acid, which is well known to be the ſame with that of Sea-ſalt. This decompoſition of Sal Ammoniac, by the metalline ſubſtances, is a full exception to the firſt column of Mr. Geoffroy's Table of Affinities, and is the baſis of ſeveral new Medicines invented by the late Comte de la Garaye †.

Corroſive Sublimate is the moſt violent and the moſt active of all corroſive poiſons. It is never uſed in Medicine, but in external applications. It is a powerful eſcharotic; it de-

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* See the Memoirs of the Academy for 1730.

† See the Memoir given in by me on this ſubject to the Academy of Sciences in the *Memoires l' Acadamie* 1754.

ſtroys proud fleſh, and cleans old ulcers: but it muſt be uſed by thoſe only who know how to apply it properly, and requires an able hand to manage it. It is not commonly applied by itſelf, but mixed in the proportion of half a dram to a pound of lime-water. This mixture is yellowiſh, and bears the name of *Aqua Phagadenica.*

Water diſſolves Corroſive Sublimate, but in a ſmall quantity. If a Fixed Alkali be mixed with this ſolution, the Mercury precipitates in the form of a red powder. If the precipitate be procured by a Volatile Alkali, it is white; if by Lime-water, it is yellow. This Mercurial Salt diſſolves pretty eaſily in boiling Spirit of Wine.

PROCESS VIII.

Sweet Sublimate.

TAKE four parts of Corroſive Sublimate; pulverize it in a glaſs or marble mortar; add by little and little three parts of Mercury revivified from Cinabar; triturate the whole carefully, till the Mercury be perfectly killed, ſo that no globule thereof can be perceived. The matter will then be grey. Put this powder into an apothecary's phial, or into a matraſs, whoſe neck is not above four or five inches long, leaving two thirds thereof empty. Set the veſſel in a ſand-bath, and put ſand round it to one third of its heighth. Apply a moderate fire at firſt; and afterwards raiſe it gradually till you perceive that the mixture ſublimes. Keep it up to this degree till nothing more will riſe, and then break the veſſel. Reject, as uſeleſs, a ſmall quantity of earth which you will find at the bottom; ſeparate alſo what adheres to the neck of the veſſel, and carefully collect the matter in the middle, which will be white. Pulverize it; ſublime it a ſecond time, in the ſame manner as before; and in the ſame manner ſeparate the earthy matter left at the bottom of the veſſel, and what you find ſublimed into the neck. Pulverize, and ſublime a third time, the white matter you laſt found in the middle. The white matter of this third ſublimation is the *Sweet Sublimate,* called alſo *Aquila Alba.*

OBSERVATIONS.

THE Acid of Sea-ſalt in the Corroſive Sublimate is very far from being perfectly ſaturated with Mercury; and thence comes the corroſive quality of this ſaline compound. But though Mercury, as appears by this combination, is capable of imbibing a much greater quantity of Acid than is neceſſary to diſſolve it; nay, though it naturally takes up this ſuperabundant quantity of Acid, yet it doth not follow from thence that this redundant Acid may not combine with Mercury to the point of perfect ſaturation, ſo as to loſe its corroſive acidity.

This is the caſe in the operation here deſcribed. A freſh quantity of running Mercury is mixed with Corroſive Sublimate; and the freſh Mercury, combining with the ſuperabounding Acid, deprives the Sublimate of its acrimony, and forms a compound which comes much nearer the nature of a Neutral Metallic Salt.

Trituration alone is not ſufficient to produce an union between the newly added Mercury and the Acid of the Corroſive Sublimate: becauſe, generally ſpeaking, the Acid of Sea-ſalt cannot diſſolve Mercury without the help of a certain degree of heat, and unleſs it be reduced into vapours.

Thus, though the newly added Mercury becomes inviſible by trituration, and ſeems actually combined with the Corroſive Sublimate, yet the union is not intimate. There is only an interpoſition of parts, but no true diſſolution of the newly added Mercury by the ſuper-abundant Acid of the Corroſive Sublimate. For this reaſon the mixture muſt be ſublimed; and by this ſublimation only is the true union effected. Nor is one ſingle ſublimation ſufficient: no leſs than three are neceſſary to deprive the Sublimate of the corroſive quality which renders it poiſonous. After the third ſublimation, the Sublimate being put upon the tongue gives no conſiderable ſenſation of acrimony; nor doth it retain any more of its former activity than is requiſite to make it a gentle purgative, when adminiſtered from ſix to thirty grains for a doſe.

If a leſs quantity of Mercury than that above directed be mixed with the Corroſive Sublimate, the ſuper-abundant Acid will not be ſufficiently ſaturated; and the leſs Mercury is added, the more of its corroſive virtue will the Sublimate retain.

If, on the contrary, a greater quantity of Mercury be added, there will be more than the Acid can poſſibly diſſolve, and the ſuperfluous quantity will remain in its natural form of Quick-ſilver. It is better therefore to err in the exceſs than in the defect of the proportion of Mercury to be added; becauſe the Corroſive Sublimate will take up no more than is neceſſary to dulcify it.

Part of the Acid of the Corroſive Sublimate is alſo diſſipated in vapours during the operation; and it is neceſſary to allow room for theſe vapours to circulate, and a vent to give them paſſage, or elſe they will burſt the veſſels. Theſe are our reaſons for leaving an empty ſpace in the ſubliming veſſels, and for having their necks no more than five or ſix inches long.

The matter which ſublimes into the neck of the veſſel is always very acrid; for which reaſon it muſt be ſeparated from the Sweet Sublimate. There remains alſo at the bottom of the matraſs an earthy, reddiſh matter; which probably comes from the Vitriol employed in making the Corroſive Sublimate. This matter muſt likewiſe be rejected as uſeleſs after every ſublimation.

PROCESS IX.

The Panacea of Mercury.

PULVERIZE ſome Sweet Sublimate, and ſublime it in the ſame manner as you did thrice before. Repeat this nine times. After theſe ſublimations it will make no impreſſion on the tongue. Then pour on it aromatic Spirit of Wine, and ſet the whole in digeſtion for eight days. After that decant the Spirit of Wine, and dry what remains, which is the *Panacea of Mercury.*

OBSERVATIONS.

THE great number of ſublimations, which the Sweet Sublimate is made to undergo, ſweeten it ſtill more, and to ſuch a degree that it leaves no ſenſation on the tongue, nor hath any purgative virtue.

The Spirit of Wine in which it is digeſted after all the ſublimations, is deſigned to blunt ſtill more the ſharpneſs of any acid particles that may not have been ſufficiently dulcified by the preceding ſublimations.

As Mercury is the ſpecific remedy for venereal diſorders, ſundry preparations thereof have been attempted with a view to produce different effects. Sweet Sublimate is purgative; and for that reaſon is not quite proper for procuring a ſalivation, becauſe it carries off the humours by ſtool. The Panacea of Mercury, which, on the contrary, is not purgative, may raiſe a ſalivation when taken inwardly.

SECTION III.

Of Operations on the SEMI-METALS.

CHAP. I.

Of ANTIMONY.

PROCESS I.

To ſeparate Antimony from its Ore by Fuſion.

HAVING drilled ſome ſmall holes, of about two lines in diameter, in the bottom of a crucible, put into it your Antimonial Ore broken into little bits, about the ſize of a hazel nut; lute on its cover; ſet the crucible thus prepared in the mouth of another crucible, and cloſe the joints with lute.

At the diſtance of half a foot from this compound veſſel place bricks all round, ſo as to form a furnace; the ſides of which muſt riſe as high as the brim of the uppermoſt crucible.

Let the bottom of this furnace be filled with aſhes, up to the top of the lower crucible, and the reſt of the furnace with lighted coals. Blow the fire, if it be neceſſary, with bellows, till the upper crucible become red. Keep it up in this degree for about a quarter of an hour. Then take your veſſels out of the furnace, and you will find the Antimony collected in the bottom of the lower crucible, having run through the holes of the upper one.

OBSERVATIONS.

THE ore of Antimony is one of the moſt fuſible: it always contains a great deal of Sulphur, and cannot ſuſtain a fire of any force without being diſſipated into vapours. It requires no additament to flux it: for it is not neceſſary, on this occaſion, that the earthy and ſtony matters mixed therewith be brought to fuſion. It is ſufficient that the Antimonial part be melted; which, as ſoon as it becomes fluid, is carried by its weight to the lower part of the crucible. Thus it is ſeparated from all heterogeneous matters; which are left in the upper crucible, while it paſſes through the holes in its bottom, and forms a maſs in the lower.

The precaution of cloſing all the apertures of both crucibles is neceſſary, on account of the volatility of this mineral: and that the Antimony, when once melted, may not continue expoſed to a great heat, it is made to run down into a veſſel ſurrounded with aſhes only, and by that means very little affected with heat; aſhes being one of thoſe ſolid mediums that tranſmit leaſt of it.

PROCESS II.

The common Regulus of Antimony.

REDUCE crude Antimony to powder. Mix it with three fourths of its weight of white Tartar, and half its weight of refined Salt-petre, both pulverized. Into a large crucible made red-hot in the fire, throw a ſpoonful of your mixture, and cover it. There will be a very conſiderable detonation. When it is over, throw in a ſecond ſpoonful of your mixture, and cover the crucible as before: this will produce a ſecond detonation. Go on thus, till you have thrown in all your mixture.

When the whole has thus fulminated, increaſe the fire ſo as to bring the matter into fuſion; that being done, take the crucible out of the furnace, and immediately pour its contents into an iron cone heated and greaſed with tallow. Strike the floor and the cone ſome gentle blows with a hammer, to make the Regulus precipitate: and when the matter is fixed and cold, invert the cone and turn it out. You will ſee it conſiſt of two diſtinct ſubſtances; the uppermoſt of which is a ſaline ſcoria, and the undermoſt the reguline part. Strike this maſs a blow with a hammer, in the place where theſe ſubſtances join, and you will by this means ſeparate the ſcoria from the Regulus; the latter of which will have the form of a metallic cone, on whoſe baſe you will obſerve the ſignature of a bright ſtar.

OBSER-

OBSERVATIONS.

ANTIMONY, though ſeparated by a former fuſion from the earthy and ſtony parts of its ore, muſt nevertheleſs be ſtill conſidered as an ore, on account of the great quantity of Sulphur it contains, which mineralizes the metalline part or Regulus. Therefore, if you deſire to have this Regulus pure, you muſt ſeparate it from the Sulphur that is combined with it. This may be done ſeveral ways. The method above propoſed is one of the readieſt and eaſieſt, though not altogether free from inconveniencies, as we ſhall ſhew.

The Salt-petre in the mixture detonates by means of the Sulphur of the Antimony, which it conſumes, and from which it ſeparates the reguline part: but leſt it ſhould alſo conſume ſome of the phlogiſton which gives the Regulus its metalline form, Tartar is added; becauſe it contains a great deal of inflammable matter, and ſo is capable of furniſhing enough for the detonation of the Nitre, or rather for reſtoring to the metallic earth of the Antimony, the phlogiſton that may be conſumed by the Nitre.

If we conſider what paſſes in this operation we ſhall ſoon be convinced that a great deal muſt be loſt in it, and that we do not thereby obtain near the whole of the Regulus that the Antimony is capable of yielding: for, 1. the Regulus of Antimony being a volatile ſubſtance, much of it muſt be diſſipated during the detonation; and ſo much the more as the detonation is frequently repeated, and continued for a conſiderable time. The flowers that may be collected by preſenting cold bodies to the ſmoke that riſes in the operation, and which may be reduced to a Regulus by the addition of a phlogiſton, ſufficiently prove what is here advanced.

2. All the Sulphur of the Antimony is not conſumed by the Nitre on this occaſion; and moreover, the Acid of that part thereof which is burnt, uniting with ſome of the Alkali produced by the deflagration of the Nitre and Tartar, forms a Vitriolated Tartar, which meeting with a ſufficient quantity of phlogiſton in the mixture produces new Sulphur. Now this Sulphur, whether not conſumed, or re-produced, in the operation, combining with the Alkali forms a Liver of Sulphur; and that diſſolves part of the Regulus, which by this means remains confounded with the ſcoria. The proof of this is, that, if the ſcoria be mixed with filings of iron, and fuſed a ſecond time, you will find at the bottom of the cru-

cible a button of Regulus, which it contained, and which is ſeparated therefrom by the interpoſition of the Iron. We ſhall ſay more on this ſubject in the proceſs for making the Martial Regulus, which immediately follows this. If, inſtead of melting the ſcoria with iron filings, we pulverize it, boil it in water, and then pour an acid into that water; the liquor will inſtantly grow turbid, and a Sulphureous Precipitate will fall, commonly called *the Golden Sulphur of Antimony;* which is nothing elſe but common Sulphur ſtill combined with ſome particles of the Regulus; a new proof of what we advanced concerning the production of Liver of Sulphur in this operation.

As Regulus of Antimony is of no great value, the loſs ſuſtained in this proceſs is ſeldom regarded. However, we ſhall have occaſion, in the ſequel, to point out a method of obtaining this Regulus with leſs diſadvantage.

PROCESS III.

Regulus of Antimony precipitated by Metals.

PUT one part of ſmall iron nails into a crucible, and ſet it amidſt burning coals, in a melting furnace. When the iron is thoroughly red-hot, and begins to grow white, add thereto little by little, and at ſeveral times, two parts of crude Antimony in powder. The Antimony will immediately flow and unite with the Iron. When the Antimony is entirely melted, add thereto, at ſeveral times, the fourth of its weight of pulverized Nitre: a detonation will enſue, and the whole mixture will be in fuſion.

After you have kept the matter in this condition for ſome minutes, pour it into an iron cone, firſt heated and tallowed. Strike the ſides of the cone with a hammer, that the Regulus may fall to the bottom; and, when all is cold, ſeparate it from the ſcoria by a blow with a hammer. Melt this firſt Regulus again in another crucible, adding a fourth part of its weight of crude Antimony. Keep the crucible cloſe ſhut, and give no more heat than is neceſſary to melt the matter. When it is in perfect fuſion, add to it at ſeveral times, as you did before, the ſixth part of its weight of pulverized Nitre; and, in half a quarter of an hour after this, pour the whole into a cone as you did the firſt time.

Laſtly, melt your Regulus over again a third, or even a fourth time, always adding a little Nitre, which will detonate as before. If after all theſe fuſions you pour the Regulus into an iron cone, you will find it very beautiful, and the ſtar well formed: it will be covered with a ſemi-tranſparent, lemon-coloured ſcoria. This ſcoria is extremely acrid and cauſtic.

OBSERVATIONS.

THOUGH Regulus of Antimony unites very readily with Sulphur, and is always found combined therewith in the earth, we muſt not thence conclude that it hath a greater affinity than other ſubſtances with that mineral: on the contrary, all the metals, except Gold, have a greater affinity than this Semi-metal with Sulphur. Hence it follows that all the metals, except Gold, are capable of decompoſing Antimony, and ſeparating the ſulphureous part from the metalline; ſo that, inſtead of employing Iron, as in our proceſs, Copper, Lead, Tin, or Silver, may be uſed, and a Regulus obtained by means thereof.

But as Iron is, of all the metallic ſubſtances, that which hath the greateſt affinity with Sulphur, it is on this occaſion preferred to the reſt. And from hence two advantages ariſe: the firſt is, that the operation is performed ſooner and with greater eaſe: the ſecond, that the Regulus is purer, and contains leſs of the precipitating metal. For it is a general rule, that, when one metallic ſubſtance is employed to precipitate another, the precipitated ſubſtance is always a little adulterated by the admixture of ſome particles of the precipitant. Now, the greater affinity the precipitant hath with the matter united to that which is to be precipitated, the leſs doth the precipitate retain of the precipitant.

In this proceſs the Iron melts very eaſily by means of the union it contracts with the Sulphur; which, as we obſerved before, hath the property of rendering this metal very fuſible, though of itſelf the moſt refractory of all.

The ſcoria found on the Regulus of the firſt fuſion is a combination of Iron with the ſulphureous part of the Antimony. This ſcoria is extremely hard, and not to be ſeparated from the Regulus without ſome trouble. The Nitre added, being alkalizated and united therewith, renders it a little ſofter, and gives it the property of relenting in the air. Any Alkaline Salt may be ſubſtituted for the Nitre.

The Nitre that is alkalizated in the operation, or the Alkali that is added, procures moreover another advantage; namely, that, by uniting with part of the Sulphur of the Antimony, it produces a Liver of Sulphur, which diſſolves the Iron, retains it, and hinders that which is not yet combined with pure Sulphur from uniting ſo readily with the Regulus as it otherwiſe would do.

Laſtly, the addition of Nitre, or an Alkali, contributes greatly to promote the fuſion, to render it more perfect, and to procure a more complete precipitation of the Regulus.

The ſecond fuſion which the Regulus is made to undergo is intended to purify it from any mixture of Iron. When the freſh Antimony added on that occaſion comes to melt with the Regulus, the Sulphur contained in the Antimony joins with the ferruginous parts in the Regulus; and the Iron becoming lighter by this union is thrown up to the ſurface of the matter. There it forms a ſort of ſcoria, with which a good deal of Antimony is mixed; the Regulus not being wholly precipitated, becauſe there is not Iron enough in the mixture for that purpoſe. The Salt-petre added here produces the ſame effect as in the firſt fuſion.

But if, on one hand, the Regulus precipitated in the firſt fuſion be purified, by this addition of freſh Antimony, from moſt of the Iron with which it was alloyed; on the other hand, this ſame Regulus cannot be kept from re-uniting with ſome ſulphureous parts.

In order therefore to ſeparate it entirely from theſe, it muſt be melted over again once or twice more, and a little Nitre added each time, to conſume them by deflagration. But this cannot be done without conſuming alſo ſome of the very phlogiſton which gives the Regulus its metalline form: whence it comes to paſs that part of the Regulus is converted to a calx, which, by means of the alkalizated Nitre, is turned into glaſs; and it is this glaſs which mixing with the ſcoria gives it the yellow colour obſerved therein. This yellow colour may alſo be in part produced by ſome ferruginous particles, of which a ſmall quantity always remains combined with the Regulus, notwithſtanding its former depuration by Antimony.

It is of no uſe to repeat the fuſions of the Regulus oftener than is above propoſed, or to add freſh Nitre with a view to conſume the Sulphur it may ſtill contain: for after the ſecond fuſion it contains none at all, and retains only the phlogiſton neceſſary to give it the metalline form. So that, by proſecuting the matter further, you would only calcine and deſtroy the Regulus to no manner of purpoſe.

From what hath been ſaid it is plain that, even by this proceſs, we do not obtain all the Regulus which our Antimony is capable of yielding; ſeeing part of it is deſtroyed by the fuſions it muſt neceſſarily undergo with Nitre, in order to its purification. We ſhall give a proceſs for obtaining from Antimony the greateſt quantity of Regulus it can poſſibly be made to yield, after we have treated of its Calcination, which is in ſome ſort the firſt ſtep of that proceſs.

PROCESS IV.

The Calcination of Antimony.

TAKE an unglazed earthen veſſel, wider at top than at bottom; put into it two or three ounces of crude Antimony finely pulverized. Set this veſſel over a weak charcoal fire, and increaſe the heat till you ſee the Antimony begin to ſmoke a little. Continue the fire in this degree, and keep inceſſantly ſtirring the Antimony with the ſhank of a tobacco-pipe all the while it is upon the fire.

The powder of Antimony, which, before calcination, was of a brilliant colour inclining to black, will become dull, and look like an earth. When it comes to have this appearance raiſe your fire till the veſſel be red-hot, and keep it up in this degree till the matter ceaſe entirely to ſmoke.

OBSERVATIONS.

ANTIMONY, as hath been already ſaid, is a ſort of ore conſiſting of a metalline or reguline part mineralized by Sulphur.

The deſign of this calcination is, by the action of fire, to diſſipate the ſulphureous part, which is the moſt volatile, in order to ſeparate it from the metalline part. It is evidently a real torrefaction; but the operation is very difficult, and requires a good deal of attention; for Antimony very eaſily melts, while at the ſame time it is neceſſary to our ſucceſs that it do not melt; becauſe when the matter is in fuſion the Sulphur requires a much greater degree of heat to carry it off. Now, as Regulus of Antimony itſelf is very volatile, a good deal of it would be diſſipated along with the Sulphur, if it were expoſed to the degree of heat neceſſary to carry off the Sulphur when the maſs is melted.

Therefore if it happen that the Antimony begin to melt during the calcination, which is eaſily perceived by its running into clots, it muſt be taken off the fire, and the clotted parts be again pulverized; after which the calcination is to be proſecuted with a leſs degree of heat.

When the Antimony has loſt all its brightneſs, and is become like an earth, it is time to augment the degree of heat, in order to complete the calcination; becauſe the laſt portions of the Sulphur are the moſt difficult to raiſe. Moreover, the inconveniences juſt mentioned are not now to be apprehended: for, as the great fuſibility of the reguline part is owing to the Sulphur, what remains, after you have diſſipated the greateſt part of the Sulphur, is much leſs fuſible; and, as the redundant Sulphur of the Antimony cannot be driven off, without diſſipating at the ſame time a good deal of the phlogiſton neceſſary to metallize its Regulus, the matter that remains comes much nearer to the nature of a calx, than to that of a metalline ſubſtance; and conſequently partakes of the nature of all metallic calces, which is to be very fixed.

Antimony may alſo be calcined, by mixing with that mineral an equal quantity of charcoal-duſt. As charcoal is incapable of fuſion, it prevents the Antimony from clotting, as well as from loſing ſo much of its metallizing phlogiſton as it otherwiſe would: and hence it comes to paſs that the calx of Antimony, prepared in this manner, comes nearer to the nature of a Regulus, than that which is prepared without addition.

If you happen to raiſe the fire too much, in this calcination with charcoal-duſt, the calx will be partly reduced to a Regulus, by means of the phlogiſton which the charcoal furniſhes; and then the Regulus will be diſſipated in vapours, eſpecially as this calx, which comes very near the nature of a Regulus, is not ſo fixed as that prepared without addition. For this reaſon it always continues to ſmoke, even when it contains no ſuperfluous Sulphur: and therefore you muſt not wait till it ceaſe to ſmoke before you put an end to your calcination; for you will loſe a great deal of it in vapours. It is time to ſtop when the vapours that riſe from it, while it is moderately red, do not ſmell of burning Sulphur.

PROCESS V.

Calx of Antimony reduced to a Regulus.

MIX the calx of Antimony, which you intend to reduce, with an equal quantity of black ſoap. This mixture will make a thin paſte. Put it little by little into a crucible, previouſly made red-hot amidſt live coals. Thus let the ſoap burn till it ceaſe to emit any oily ſmoke. Then cover the crucible; make the fire ſtrong enough to melt the matter, and you will hear it effervеſce and boil. When this noiſe is over let the crucible cool, and then break it: you will find in it a beautiful ſcoria, marked with circles of ſeveral colours; and under that a button of Regulus, which is not yet quite pure, and muſt be purified in the following manner.

Pound this Regulus, and mix it with half its weight of an antimonial calx as perfectly deſulphurated as poſſible. Put it into a crucible, and cover it: melt the whole, ſo that the ſurface of the melted matter may be ſmooth and uniform. Let the crucible cool, and then break it: you will find in it a beautiful button of very pure Regulus, covered with a ſcoria having the appearance of an opaque glaſs, or a kind of greyiſh enamel, moulded on the finely radiated ſurface of the Regulus.

OBSERVATIONS.

OF all the metalline calces that of Antimony is moſt eaſily reduced. Any matter that contains the phlogiſton, even charcoal-duſt alone, is ſufficient to procure it the form of a Regulus, without the addition of any thing to facilitate its fuſion; becauſe this calx, which is not of itſelf altogether refractory, becomes ſtill more fuſible as it combines with the phlogiſton, and approaches to the reguline ſtate.

Though all inflammable matters are capable of procuring the reduction of the calx of Antimony, yet there are ſome with which the operation ſucceeds better, and produces a greater quantity of Regulus, than it does with others. Fatty matters, joined with Alkalis, are thoſe which anſwer beſt in this reduction, as they do in moſt others. The black flux, for inſtance, is very proper for this purpoſe: but Mr. Geoffroy, who made many experiments on Antimony, found by repeated trials that black ſoap is ſtill fitter for it, and that a greater quantity of Regulus was obtained by its means, than by any other reducing flux whatever. The proceſs here given is taken from one of the Memoirs on this ſubject, which he laid before the Academy of Sciences.

Black ſoap is made of the lye of a Fixed Alkali, ſuch as pot-aſh for inſtance, with quick-lime, incorporated by boiling with oil of lint-ſeed, rape-ſeed, or hemp-ſeed, and ſometimes alſo with animal fat. The oily matters, contained in this reducing flux, are firſt burnt and charred to a coal in the crucible. As ſoon as they are brought to this ſtate, the crucible is covered, and the fire is increaſed, till the matters melt. At that inſtant the reduction begins to take place; and the bubbling noiſe obſerved is an effect thereof.

The Regulus obtained by this firſt fuſion is not yet very pure, being adulterated with the mixture of ſome unmetallic earth that was contained in the Antimony, and with a portion of the calcarious earth of the ſoap.

Mr. Geoffroy found that his Regulus was contaminated with this ſubſtance, by putting it into water: for on that occaſion he obſerved a very briſk ebullition about the reguline buttons, which ſometimes laſted above four and twenty hours; and on examining them with a glaſs, he diſcovered ſome little holes, imperceptible to the naked eye, through which the water entered, to unite with the lime retained in the internal parts of the Regulus, which having been re-calcined in the operation required to be ſlaked.

This Regulus may be purified by ſimple fuſion, without any additament, becauſe the particles of lime, being lighter than thoſe of the Regulus, will be thrown up to the ſurface, on which they will form a ſort of ſcoria. But Mr. Geoffroy took notice that, in this caſe, the ſurface of the Regulus is never very neat; that it is always ſullied with a very adheſive ſcoria, and that no ſtar is formed upon it. Beſides, the Regulus muſt be kept a long while in very thin fuſion, that the heterogeneous matters, which hinder the perfect re-union of its parts, may have time to riſe to the ſurface by their lightneſs. But the longer the Regulus is kept in fuſion, the more of it evaporates, becauſe of its volatility. He was therefore obliged to have recourſe to other means.

We have in the proceſs deſcribed the method which ſucceeded beſt with Mr. Geoffroy. It conſiſts in melting the Regulus over again, with the addition of a little freſh calx of Antimony thoroughly freed from its Sulphur. This calx being in its nature eaſily vitrifiable, and combining with the earthy parts that deprave the Regulus, and which cannot be vitrified without addition, ſcorifies theſe matters, and with them forms the opaque glaſs, or kind of enamel which is found over the Regulus purified in this manner.

The ſtar on that part of the Regulus of Antimony, which was contiguous to the ſcoria, is a mark of its purity, and a proof that the operation was well performed. This ſtar is nothing but a particular diſpoſition of the parts of the Antimony, which have the property of running naturally into facets and needles. The perfect fuſion, both of the Regulus and the ſcoria that covers it, leaves the parts of the Regulus at liberty to range themſelves in this order. This diſpoſition appears not only on the upper ſurface of the Regulus, but, if you break the button, you find the ſame in its internal parts. There are ſome round pyrites whoſe inſides have nearly the ſame appearance, and ſeem to conſiſt of rays iſſuing from a common center.

The quantity of Regulus obtained by Mr. Geoffroy's proceſs is more than double of what is procured in the common way, which yields but about four ounces in the pound; whereas this gives from eight to ten ounces.

When Antimony is calcined with charcoal-duſt, what remains after the diſſipation of all the Sulphur is not, properly ſpeaking, a calx of Antimony; but a ſort of Regulus quite formed, and differing from the common Regulus only in that its parts are diſunited, and not collected into a maſs. For if this pretended calx of Antimony be melted, it directly coaleſces into a Regulus, without the addition of any inflammable matter fit to procure its reduction. Indeed leſs Regulus is obtained by this means than when a reductive is added: but nevertheleſs this experiment ſtill proves what I advanced; ſeeing Regulus of Antimony cannot be melted without loſing more or leſs thereof, either becauſe ſome of it is diſſipated in vapours, or becauſe part of it loſes its phlogiſton in the fuſion, and ſo is converted into a calx.

PROCESS VI.

Antimony calcined with Nitre. Liver of Antimony. Crocus Metallorum.

PULVERIZE and mix perfectly together equal parts of Nitre and Antimony: put the mixture into an iron mortar, and cover it with a tile, which however muſt not ſhut it quite cloſe. With a live coal ſet fire to the matter in the mortar, and immediately withdraw it. The mixture will flame, with great detonation; which being over, and the mortar cooled, invert it, and ſtrike its bottom to make all the matter fall out. Then, by a blow with a hammer, ſeparate the ſcoria from the ſhining part, which is the *Liver of Antimony*.

OBSERVATIONS.

In this operation the Nitre takes fire and detonates with the Sulphur of the Antimony; and nothing remains but the metallic earth of the mineral, which, meeting with no ſubſtance to reſtore its phlogiſton, cannot take the form of a Regulus; but, being combined with a large quantity of fuſed ſaline matters, begins itſelf to flow, and forms a ſort of vitrification; which, however, is not a complete one, becauſe the matters do not continue long enough in fuſion, but cool too ſoon. This preparation of Antimony is a violent Emetic. It is uſed to make Emetic Wine and Tartar Emetic: it is alſo given in ſubſtance to horſes.

The ſaline matters found after the operation in the form of a ſcoria, or perhaps confounded with the Liver of Antimony, are combinations of Fixed Nitre, partly with the Acid of the burnt Sulphur, forming a Neutral Salt of the ſame kind as Vitriolated Tartar, and partly with ſome unburnt Sulphur, forming a ſort of Liver of Sulphur that contains a little Regulus. It is uſual to pulverize this Liver of Antimony and waſh it with water, in order to diſſolve and carry off all the Salts. When thus pulverized and waſhed it is called *Crocus Metallorum*. If Liver of Antimony be melted with any inflammable matter, it will be reduced to a Regulus; becauſe it is nothing but a metalline calx half vitrified.

PROCESS VII.

Another Calcination of Antimony with Nitre. Diaphoretic Antimony. Materia Perlata. Clyſſus *of Antimony.*

MIX one part of Antimony with three parts of Nitre; project this mixture by ſpoonfuls into a crucible kept red-hot in a furnace. Each projection will be attended with a detonation. Continue doing this till you have uſed all your mixture: then raiſe the fire, and keep it up for two hours; after which throw your matter into a pan full of hot water. Let it lie ſteeping in water kept hot for a whole day. Then pour off the liquor: waſh the white powder you find at bottom in warm water; and repeat the ablutions till the powder become inſipid. Dry it, and you have *Diaphoretic Antimony.*

OBSERVATIONS.

THIS operation differs from the preceding one, in reſpect of the quantity of Nitre deflagrated with the Antimony. In the former we added one part only of Nitre to one part of Antimony; but in this three parts of Nitre are put to one of the mineral; and the calx reſulting from this mixture is of courſe very different from the other.

In the firſt place, Liver of Antimony hath a reddiſh colour; whereas Diaphoretic Antimony is very white. Secondly, Liver of Antimony is in a manner half vitrified; Diaphoretic Antimony is, on the contrary, in the form of a powder, the parts of which have no connection together.

The reaſon of theſe differences will eaſily appear, if we conſider, that, Liver of Antimony being the reſult of calcination with one part of the Nitre only, which is not ſufficient to conſume all the Sulphur of the mineral, what remains after the detonation is not entirely deprived of its phlogiſton; from whence ariſe the colour it retains, and the eaſe with which it flows in the fire: but that, when three parts of Nitre are added inſtead of one, this quantity is not only ſufficient to conſume all the Sulphur and the phlogiſton of the Antimony, but even more than enough; ſeeing that, after the operation, ſome Nitre is ſtill found undecompoſed.

The calx of Antimony, prepared by calcining it with three parts of Nitre, is therefore deprived of all its phlogiſton. This is the cauſe of its whiteneſs, and the reaſon why it is not half vitrified by the operation, as Liver of Antimony is: for we know that the more a metallic calx is deprived of its phlogiſton, the leſs fuſible and the leſs vitrifiable it is. This calx of Antimony bears the name of *Diaphoretic Antimony*, or *Diaphoretic Mineral:* becauſe, being neither emetic nor purgative, it is thought to have the virtue of promoting perſpiration.

Antimony may be calcined with various proportions of Nitre, between that uſed to make Liver of Antimony, and this with which Diaphoretic Antimony is prepared; and from theſe calcinations will reſult calces poſſeſſed of properties both chymical and medical, of an intermediate nature between the extremes of thoſe two preparations. The nearer the proportion of Nitre comes to that employed in preparing Liver of Antimony, the more will the reſulting calx reſemble that preparation; and in the ſame manner, a calx prepared with a greater proportion of Nitre will ſo much the more reſemble Diaphoretic Antimony, as the proportion of Nitre uſed comes nearer three parts of Nitre for one of Antimony.

It is not neceſſary that Antimony in ſubſtance be employed to make the Diaphoretic Mineral: you may, if you pleaſe, make uſe of its Regulus. But as the Regulus contains no Sulphur, nor any more phlogiſton than is requiſite to ſecure its metalline form, it is needleſs to put three parts of Nitre to one of Regulus; an equal quantity thereof being ſufficient.

The matter is projected by ſpoonfuls, to the end that, by gradual and repeated detonations, the Antimony may be more perfectly calcined: it is alſo with a view to deſtroy entirely the ſmall remainder of phlogiſton, which may have eſcaped the action of the Nitre, that the matter is kept red-hot in the crucible for two hours.

The whole is afterwards thrown into hot water, and left ſteeping therein for ſeveral hours, with deſign to give the water time to diſſolve all the ſaline matters that are mixed with the Diaphoretic Calx. When crude Antimony is uſed in making this preparation, theſe ſaline matters are, 1. an Alkalizated Nitre; 2. a Neutral Salt formed by the union of the Acid of Sulphur with part of that Alkali, as in the preparation of Liver of Antimony; 3. a portion of undecompoſed Nitre.

The water in which the Diaphoretic is waſhed takes up moreover a portion of the calx of Antimony, which is exceeding finely attenuated, and continues united with the fixed Nitre, and ſuſpended therewith in the liquor. This matter is to be ſeparated from the Fixed Nitre, by mixing the water wherein it is diſſolved with an Acid, which unites with the Alkali, and precipitates this matter in the form of a white powder, to which the name of *Materia Perlata* hath been given. Becauſe it is precipitated in the ſame manner as the Golden Sulphur of Antimony, and, like that, is found in the water with which the ſaline matters are waſhed out, after the detonation of Nitre with Antimony, ſome

Chymiſts have given it, though very improperly, the name of the *Fixed Sulphur of Antimony*.

This matter is a true Calx of Antimony, and differs from Diaphoretic Antimony in nothing but its being ſtill more perfectly calcined. It is ſo indeed to ſuch a degree that it is impoſſible to reſtore its metalline form, or reduce it to a Regulus, by the addition of an inflammable matter. Diaphoretic Antimony, on the contrary, may be re-metallized, by ſupplying it with phlogiſton: but it muſt be obſerved that, in whatever manner you go about this, you will obtain a much ſmaller quantity of Regulus, than when you uſe a Calx of Antimony prepared with a ſmaller quantity of Nitre.

If you attempt to reduce either Liver of Antimony or Diaphoretic Antimony, great care muſt be taken to waſh them thoroughly, in order to free them from every thing ſaline: for, without this precaution, the Acid of the Sulphur, having, as was obſerved, formed a Neutral Salt with the Alkali of the Nitre, will combine with the inflammable matter added to revivify the calx of Antimony and reproduce a Sulphur; which, uniting afterwards with the ſame Alkali, will produce a Liver of Sulphur, that will diſſolve part of the Regulus, hinder its precipitation, and greatly leſſen the quantity which might otherwiſe be expected.

A particular ſort of Diaphoretic Antimony is ſometimes prepared for Medical uſes, which hath a purgative quality: it is not waſhed at all, and is therefore called *Unwaſhed Diaphoretic Mineral*

Diaphoretic Antimony may alſo be prepared in cloſe veſſels, by means of which the vapours that riſe during the operation are retained. For this purpoſe a tubulated retort is employed, having a ſeries of adopters fitted to it. The retort is placed in a furnace, and heated till its bottom become red: then a very ſmall quantity of the mixture, for making Diaphoretic Antimony, is introduced through the tube in the upper part of the retort, and the tube immediately ſtopped. A detonation enſues, and the vapours expand themſelves into the adopters, where they condenſe. This is repeated till the intended quantity of matter be uſed. After the operation ſome white flowers are found ſublimed in the neck of the retort, and a ſmall quantity of liquor in the recipients. This liquor is acid. It conſiſts of ſome of the Acid of the Nitre, which the Acid of the Sulphur hath expelled from its baſis, and alſo a little of the Acid of the Sulphur carried up by the heat before it could combine with the baſis of the Nitre. This liquor is called *Clyſſus of Antimony.* The name of *Clyſſus* is given to all liquors in general that are prepared by this method.

The white flowers found in the neck of the retort are flowers of Antimony; that is, a calx of Antimony forced up by the heat, and by the impetus of the detonation. Theſe flowers may be reduced to a Regulus. What remains in the retort is the ſame with the matter that remains in the crucible, wherein the mixture of Nitre and Antimony for making Diaphoretic Antimony hath been deflagrated.

Neither Diaphoretic Antimony nor the Pearly matter are ſoluble in any Acid.

PROCESS VIII.

Calx of Antimony Vitrified.

TAKE any quantity you pleaſe of calx of Antimony, made without addition; put it into a good crucible, which ſet in a melting furnace: kindle the fire gradually, and leave the crucible uncovered at the beginning.

A quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorouſly till the calx melt. You may know when it is thoroughly melted, by dipping into the crucible an iron wire, to the end of which a little knob of glaſs will adhere, if the matter be in perfect fuſion. Keep it in fuſion for a quarter of an hour, or rather longer if your crucible can bear it. Then take it out of the furnace, and immediately pour out the melted matter on a ſmooth ſtone, made very hot for the purpoſe: it will preſently fix into a yellow Glaſs.

OBSERVATIONS.

ALL the calces of Antimony, when expoſed to a violent fire, are converted into Glaſs; but not all with the ſame facility. In general, the more of their phlogiſton they have loſt in the calcination, the more difficult is their vitrification. This cauſes alſo a difference in the colour of the Glaſs; which will be of ſo much a deeper yellow, and the nearer to a red, the leſs the Antimony was calcined.

It frequently happens, when we employ a calx of Antimony which is not ſufficiently deprived of its phlogiſton, that we find in the crucible a button of Regulus, which, being

ing heavier than the Glaſs, always lies at the bottom. With a view to avoid this inconvenience, and to diſſipate completely the exceſs of phlogiſton that may ſtill be left in the calx of Antimony, we direct the crucible to be left uncovered for ſome time, at the beginning of the operation. If, notwithſtanding this precaution, any Regulus be ſtill found at the bottom of the crucible, and you reſolve to vitrify it, the crucible muſt be returned to the furnace, and the fuſion continued; by which means the Regulus will at laſt be converted into Glaſs.

If, on the contrary, you meet with any difficulty in effecting the vitrification, on account of your having employed a calx that hath loſt too much of its phlogiſton, ſuch as Diaphoretic Antimony, or the Pearly matter, the fuſion may be greatly facilitated by throwing into the crucible a little crude Antimony.

Glaſs of Antimony is a moſt violent emetic. This Glaſs, as well as Liver of Antimony, is employed in preparing Emetic Wine and Emetic Tartar.

It may be reſuſcitated, like the calces of Antimony, into a Regulus, by reuniting it with a phlogiſton. For this purpoſe it muſt be finely pulverized, thoroughly mixed with ſome black flux, and melted in a covered crucible. This Glaſs, as well as that of Lead, hath the property of greatly promoting the vitrification of matters that are to be ſcorified.

PROCESS IX.

Kermes Mineral.

BREAK any quantity you will of Hungarian Antimony into little bits: put it into a good earthen coffee-pot: pour on it twice its weight of rain-water, and a fourth part of its weight of well filtered liquor of Nitre fixed by charcoal. Boil the whole briſkly for two hours, and then filter the liquor. As it cools it will acquire a red colour, grow turbid, and leave a red powder on the filter.

Return your Antimony into the coffee-pot. Pour on it as much rain-water as before, and three fourths of the former quantity of the liquor of Fixed Nitre. Boil it again for two hours, and then filter the liquor. It will again depoſite a red ſediment. Return your Antimony into the coffee-pot: pour on it the ſame quantity of rain-water, and half the firſt quantity of the liquor of Fixed Nitre. Boil it again for two hours, and then filter the liquor as formerly. Waſh all theſe ſediments with warm water, till they become inſipid; then dry them, and you have the *Kermes Mineral.*

OBSERVATIONS.

If you recollect what we ſaid concerning the property which Fixed Alkalis poſſeſs of uniting with Sulphur, both by fuſion, and, when thoſe Salts are reſolved into a liquor, by boiling, and of forming therewith a Liver of Sulphur, which diſſolves all metalline ſubſtances, you will readily comprehend the nature of this Kermes.

Antimony conſiſts of a ſulphureous and a reguline part. Therefore, if this mineral be boiled in a ſolution of a Fixed Alkali, ſuch as Nitre fixed by charcoal, the Alkali will diſſolve the Sulphur of the Antimony, and form therewith a Liver of Sulphur, which, in its turn, will diſſolve the reguline part. Now, Kermes Mineral, prepared as above directed, is no other than a Liver of Sulphur combined with a certain quantity of Regulus of Antimony.

Mr. Geoffroy hath ſet this truth in the cleareſt light, by his accurate analyſis of the Kermes Mineral. The experiments he made on that ſubject are circumſtantially related in ſeveral Memoirs printed in the volumes of the Academy for 1734 and 1735. By combining Acids with the Kermes he demonſtrated, 1. the exiſtence of Sulphur in this compound; having ſeparated from it a burning Sulphur, which cannot be miſtaken for any other than the Sulphur of Antimony. In order to obtain this Sulphur pure, an Acid muſt be employed that will not only abſorb the Alkali, but alſo perfectly diſſolve the reguline part that might otherwiſe remain united with the Sulphur. *Aqua regia* was the Acid which ſucceeded beſt with Mr. Geoffroy. 2. He alſo proved that there is a Fixed Alkali in the compoſition of the Kermes; ſeeing the Acids with which he precipitated the Sulphur became Neutral Salts, and juſt ſuch as thoſe very Acids combined with a Fixed Alkali would have conſtituted: that is, the Vitriolic Acid produced a *Sal de duobus;* the Nitrous Acid a regenerated Nitre; and the Marine Acid a regenerated Sea-ſalt. 3. Mr. Geoffroy demonſtrated the reguline part of Antimony to be an ingredient in the Kermes; having procured therefrom an actual Regulus of Antimony, by fuſing it with the black flux.

In preparing the Kermes it is neceſſary to renew the liquor from time to time, as above directed; becauſe, when it is once impregnated with Kermes to a certain degree, it can take up no more; and conſequently the ſame liquor cannot operate again on the Antimony. Experience hath ſhewn, that, if the doſes above preſcribed be applied, the liquor will after two hours boiling be ſufficiently ſaturated with Kermes.

If the liquor in which the Kermes is diſſolved be filtered while it is very hot, and almoſt boiling, it leaves nothing on the filter; the Kermes paſſing through with it: but as it cools it grows turbid, and gradually depoſites the Kermes. Therefore it ought not to be filtered till it be cold; or, if it be filtered while it is boiling hot, in order to ſeparate from it ſome coarſe particles of Antimony not yet converted into Kermes, it muſt be filtered a ſecond time when it is cold, in order to get the Kermes.

Though in the method uſually practiſed for making Kermes, the Antimony is boiled only thrice, yet it does not follow that more Kermes may not be obtained from it, or that but little more would be obtained by a fourth and fifth boiling; on the contrary, it would yield conſiderably more. Mr. Geoffroy obſerved, that he got more Kermes by the ſecond boiling than by the firſt, and ſtill more by the third than by the ſecond; and that the yield goes on increaſing in this manner to a very great number of times, which he hath not determined. This increaſed effect ariſes from hence, that by multiplying the frictions of the little bits of Antimony againſt each other, new ſurfaces are expoſed to the action of the Alkaline liquor, and furniſh it with more Sulphur; while the addition of this ſulphur renders the hepar more active and more penetrating; or, if you pleaſe, produces a new hepar every time the matters are boiled. When the Alkaline liquor is once ſaturated with Kermes, it ceaſes to act, and forms no new hepar; but it does not follow that its virtue is quite exhauſted. To reſtore its ability of acting as well as at firſt, or nearly ſo, you need only let it cool, and depoſite the Kermes diſſolved in it. We owe this ſingular obſervation alſo to Mr. Geoffroy: he had the patience to go through no leſs than threeſcore and ten boilings with the ſame liquor, without adding any thing but rain water, to ſupply the place of what was diſſipated by evaporation: and he always obtained a pretty conſiderable quantity of Kermes by each boiling, for the reaſon given above.

Boiling is not the only means of making Kermes. Mr. Geoffroy found the way of making it by fuſion. For this purpoſe you muſt mix accurately one part of very pure Fixed Alkali, dried and pulverized, with two parts of Hungarian Antimony alſo pulverized, and melt the mixture. Mr. Geoffroy made uſe of a retort. When the maſs is melted, it muſt again be pulverized, while it is ſtill hot, and then put into, and kept in, boiling hot water for an hour or two; after which the liquor, now become ſaline and antimonial, muſt be filtered into another veſſel filled with boiling water. Every ounce of Antimony treated in this manner yields, by thrice boiling the melted maſs, from ſix drams to ſix drams and a half of Kermes; which differs from the Kermes made by boiling, only in that it is not quite ſo ſoft to the touch, having in every other reſpect the ſame qualities.

As Liver of Sulphur is made two different ways, to wit, by boiling and by fuſion, and as the Kermes is nothing but a Liver of Sulphur in which the reguline part it diſſolved; it follows that Kermes may be made by fuſion as well as by boiling. It is neceſſary to pulverize the melted maſs, and to ſteep it in boiling hot water for an hour or two, that the water may diſſolve and divide it ſufficiently to make the Kermes fine and beautiful.

With the ſame view, that is, to make it finer and more perfect, Mr. Geoffroy orders the water ſaturated with the Kermes made by fuſion, to be received, when filtered, in a veſſel full of other boiling-hot water. He obſerved, that when the liquor impregnated with Kermes cools too faſt, the Kermes that precipitates is much coarſer. The warm ſolution of Kermes is diffuſed through the boiling-hot water into which it is filtered, and is thereby enabled to retain its heat ſo much the longer.

From what hath been ſaid on the nature of Kermes, it plainly appears that there muſt be a great reſemblance between it and the Golden Sulphur of Antimony, obtained from the ſcoria, either of plain Regulus of Antimony, or of the Liver of Antimony; this Golden Sulphur being no other than a portion of the Antimony combined with the Nitre alkalizated during the operation.

Yet there is a difference in the manner of precipitating theſe two compounds: for the Kermes precipitates ſpontaneouſly, on the bare cooling of the water in which it is diſſolved; whereas an Acid is employed to precipitate the Golden Sulphur ſuſpended in the water, with which the ſcoria of the plain Regulus of Antimony, or that of Liver of Antimony, hath been waſhed. This gives ſome ground to ſuſpect that the reguline part is not ſo intimately united with the

Liver of Sulphur in the Kermes, as in the ſcoriæ from which the Golden Sulphur is obtained.

PROCESS X.

Regulus of Antimony diſſolved in the Mineral Acids.

COmpound an *aqua regis* by mixing together four meaſures of Spirit of Nitre, and one meaſure of Spirit of Salt: on a ſand-bath moderately heated place a matraſs, into which pour ſixteen times as much of this *aqua regis* as you have Regulus to diſſolve. Break your Regulus into little bits; and throw them ſucceſſively one after another into the matraſs, obſerving not to add a new one till that put in before is entirely diſſolved: continue this till your Regulus be all uſed. By degrees, as the diſſolution advances, the liquor will acquire a beautiful golden colour; which, however, will inſenſibly diſappear, as the white fumes that continually aſcend from it evaporate.

OBSERVATIONS.

REGULUS of Antimony is one of thoſe metalline ſubſtances that diſſolve with the greateſt difficulty. Not but that moſt of the Acids attack and corrode it; but they do not make a clear, limpid ſolution thereof: they in ſome ſort only calcine it, and this ſemi-metal, as faſt as it diſſolves, precipitates of its own accord in the form of a white magiſtery. In order to effect a complete diſſolution thereof, it is neceſſary to employ an *aqua regis* compounded as directed, and in the doſe preſcribed in the proceſs, which is wholly taken from Mr. Geoffroy's Memoirs on Antimony mentioned above.

If, inſtead of the Regulus, ſmall bits of crude Antimony be thrown into the *aqua regis*, the Acid will attack and diſſolve the reguline part, and ſo ſeparate it from the ſulphureous part which it will not touch. When the diſſolution is finiſhed, the particles of Sulphur being now become lighter, becauſe no longer united with the metalline part, will float upon the liquor. Being collected they form a true Sulphur, which ſeems no way different from common brimſtone. This operation, you ſee, is a ſort of Parting Proceſs.

The Vitriolic Acid, whether concentrated or much weakened with water, does not act when cold either on Antimony or on its Regulus. This Acid only dims the ſplendour of the facets of the Regulus; but if one part of exceeding pure Regulus of Antimony be put into a retort, and four parts of clear concentrated Oil of Vitriol poured on it, as ſoon as the Acid is heated it turns brown, and emits a moſt ſuffocating ſmell of Sulphur, which increaſes as the Regulus is penetrated and corroded by the Acid.

On raiſing the fire, there ſeparates from it a matter that ſeems mucilaginous; and when the Acid hath boiled ſome time, the Regulus is converted into a white ſaline maſs, as Mercury is in the preparation of Turbith mineral. At the ſame time a little Sulphur ſublimes into the neck of the retort. At laſt all the Oil of Vitriol paſſes over into the receiver, and leaves the Regulus in a white, ſpungy, ſaline maſs in the retort. When the fire is out, the veſſels unluted, and the receiver ſeparated from the retort, there riſes a white vapour like that of the ſmoking liquor of Libavius.

The ſaline maſs left in the retort, after the operation, is found increaſed to near double its weight: this increaſed weight is owing to the Acid that hath united with the Regulus.

This combination of the Vitriolic Acid with the Regulus of Antimony is exceſſively cauſtic, and cannot, for that reaſon, be adminiſtered internally.

The pureſt Spirit of Salt hath no ſenſible effect either on Antimony or its Regulus: but if Antimony be coarſely pounded, it ſeparates therefrom, though ſlowly, ſome light, ſulphureous flakes.

The action of Spirit of Nitre on this metallic ſubſtance is more perceptible: by little and little it attacks the plates of the Antimony, which diſcharge a great number of air-bubbles. As the diſſolution advances, the Acid acquires a greeniſh colour inclining to blue; and if there be not too much of it, it will be almoſt entirely imbibed by the Antimony, penetrate between its *laminæ*, and exfoliate them in the direction of the needles that compoſe them. If there be too much of the Acid, that is, if it riſe above the Antimony, it will deſtroy theſe plates, and reduce them to a white powder.

But when the Acid is imbibed ſlowly, we diſcover between the ſwelled *laminæ* little ſaline tranſparent cryſtals, that vegetate much in the ſame manner as thoſe of the pyrites, in which ſmall cryſtals of Vitriol are frequently obſerved, whoſe figures are not very well determined. Theſe little cryſtals between the Antimonial plates are intermixed with yellow particles, which being carefully ſeparated burn like common Sulphur.

All theſe uſeful obſervations, concerning the action of the Acids on Antimony and its Regulus, we owe likewiſe to Mr. Geoffroy; who adviſes the collecting a quantity of theſe little cryſtals in time; becauſe they diſappear ſoon after they are formed, being probably covered by the white powder, or magiſtery, which is continually produced as faſt as the Nitrous Acid diſunites and ſeparates the needle-like fibres of the Antimony.

Mr. Geoffroy obſerved the ſame ſort of cryſtals on the Regulus of Antimony, when ſubſtituted for crude Antimony in this experiment; but it requires a great deal of care to ſeparate theſe cryſtals; for as ſoon as the air comes into contact with them they loſe their tranſparency; and if you wait till the Regulus be in ſome meaſure converted into a magiſtery, they are not then to be diſtinguiſhed.

In order therefore to have a good view of theſe cryſtals, the Regulus muſt be broken to pieces; theſe pieces put in a glaſs baſon, and Spirit of Nitre poured on them to half their heighth, but not to cover them. This Acid penetrates them, exfoliates them in white ſcales; and on the ſurface of theſe ſcales the cryſtals ſhoot of a dead-white colour. In two or three days time theſe cryſtals vegetate and grow in the form of cauli-flowers: they muſt then be gathered, to prevent their being confounded in the white magiſtery which continues to be produced, and would not ſuffer them to be diſtinguiſhed. If you attempt to diſſolve the reguline part of Antimony by an *aqua regis* compounded in different proportions, and applied in a different doſe from what is preſcribed in the proceſs, the Regulus of Antimony will only be calcined, as it is by the other Acids, and will precipitate in the form of a white magiſtery as faſt as it diſſolves, ſo that no part thereof will remain united with the ſolvent. The proof of this is, that if an alkaline liquor be poured, even to the point of ſaturation, upon the *aqua regis* that hath thus dropt the Antimony, no new precipitate will be depoſited.

PROCESS XI.

Regulus of Antimony combined with the Acid of Sea-ſalt. Butter of Antimony. Cinabar of Antimony.

PULVERIZE and mix thoroughly ſix parts of Regulus of Antimony, and ſixteen parts of Corroſive Sublimate. Put this mixture into a glaſs retort that hath a wide ſhort neck, and let one half of its body at leaſt be left empty. Set it in a reverberatory furnace, and having fitted a recipient thereto, and luted the joint, make a very ſmall fire at firſt, to heat it ſlowly. Increaſe it afterwards by degrees, till you ſee a liquor aſcend from the retort that grows thick as it cools. Keep up the fire to this degree as long as you ſee any of this matter come over.

When no more riſes with this degree of fire, unlute your veſſels, take off the receiver, and in its place ſubſtitute another filled with water. Then increaſe your fire by degrees till the retort be red-hot. Some running Mercury will fall into the water, which you may dry and keep for uſe; it being very pure.

OBSERVATIONS.

In our obſervations on the preceding proceſs, we took notice that the pureſt Marine Acid, in the form of a liquor, will not diſſolve the reguline part of Antimony. Here this very Acid combined with Mercury, and applied in a dry form to the Regulus of Antimony, quits the Mercury with which it was united, in order to join this very Regulus, as having a greater affinity therewith. This operation is a further proof of what we advanced on the ſubject of Mercury; to wit, that ſeveral metallic ſubſtances, which are not ſoluble by certain Acids when in a fluid ſtate, may be diſſolved by thoſe Acids when moſt highly concentrated; as they are when combined with any other ſubſtance in a dry form, and are ſeparated from it by the force of fire. Their efficacy is alſo further promoted by their being reduced, on this occaſion, into ſubtile vapours.

The Marine Acid combined with the reguline part of Antimony doth not form a hard, ſolid compound; but a kind of ſoft ſubſtance, that melts in a very gentle heat, and alſo becomes fixed by the leaſt cold, much in the ſame manner as butter; and from this property it hath its name.

Soon after mixing the Regulus with the Corroſive Sublimate, the matter ſometimes grows conſiderably hot: this is occaſioned by the Marine Acid's beginning to act on the reguline part, and to deſert its Mercury.

The Butter of Antimony riſes with a very moderate heat; becauſe the Acid of Sea ſalt hath the property of volatilizing, and carrying up along with it, the metallic ſubſtances with which it is combined: and for this reaſon a very gentle heat only is required at the beginning of the operation.

It is abſolutely neceſſary that the neck of the retort be wide and ſhort: for otherwiſe if the Butter of Antimony ſhould fix and be accumulated therein, it might ſtop up the paſſage entirely, and occaſion the burſting of the veſſels. By this operation we obtain eight parts and three quarters of fine Butter of Antimony, and ten parts of running Mercury; there being left in the retort one part and a half of a rarefied matter, black, white, and red. This is probably the moſt earthy and moſt impure part of the Regulus of Antimony.

It is of the utmoſt conſequence to the operator that he avoid with the greateſt care the vapours that iſſue from the veſſels, becauſe they are extremely noxious, and may occaſion mortal diſorders. The Butter of Antimony is a moſt violent Corroſive and Cauſtic.

When all the Butter is riſen, the receiver is ſhifted in order to receive the Mercury; which, being diſengaged from the Acid that gave it a ſaline form, appears in its natural form of Quick-ſilver: but it requires a much greater degree of heat than the Butter of Antimony to raiſe it by diſtillation.

If crude Antimony, inſtead of Regulus of Antimony, be mixed with Corroſive Sublimate, a Butter of Antimony will be obtained in the ſame manner; but, inſtead of having a running Mercury after the Butter, you will find a Cinabar ſublimed into the neck and upper concavity of the retort.

The reaſon of this difference is eaſily conceived: for when the Regulus is uſed, the Mercury being deſerted by its Acid finds no other ſubſtance to unite with, and ſo riſes in the form of Quick-ſilver; but when crude Antimony is employed inſtead of its Regulus, as the reguline part thereof cannot combine with the Acid without quitting its Sulphur, ſo this Sulphur, being at liberty, unites with the Mercury, which is ſo likewiſe, and therewith forms a Cinabar; which from its origin is named *Cinabar of Antimony*. When you intend to make both Butter and Cinabar of Antimony at the ſame time, ſix parts of Antimony muſt be mixed with eight of Corroſive Sublimate; and care muſt be taken, while the Butter is coming over, to warm the neck of the retort by holding ſome live coals near it, with the precautions neceſſary to avoid breaking it. This warmth makes the Butter melt and run into the receiver; whereas, being thicker and of a much denſer conſiſtence than that made with the Regulus, it would otherwiſe gather in the neck of the retort, choak it entirely, and burſt the veſſel.

When the Butter is drawn from crude Antimony, more circumſpection is neceſſary to make it of a beautiful white colour, than when it is obtained from the Regulus: for, if the fire be too ſtrong during the diſtillation, or if the receiver be not ſoon enough ſeparated from the neck of the retort, certain red ſulphureous vapours, the fore-runners of the Cinabar, will at laſt aſcend, and mixing with the Butter give it a brown colour.

In order to reſtore its beauty it muſt be put into a clean retort, and rectified by diſtilling it over again with a gentle ſand-heat. By this rectification the Butter of Antimony becomes more fluid; and by re-diſtilling it a ſecond time you may give it the thinneſs and fluidity of an oil.

After the operation there will be found in the receiver three parts and three quarters of Butter of Antimony, and ſome ſmall cryſtals adhering to its inſide, in the form of ſprigs. When you break the retort there exhales from it a ſulphureous odour; and you will find in it ſeven parts of Cinabar of Antimony, the greateſt part of which is uſually in compact glebes, that are heavy, ſmooth, ſhining, blackiſh throughout moſt of the maſs, but in ſome places red: another part thereof appears in ſhining needles, and the reſt in powder.

When all the Butter of Antimony is come over, and you begin to ſee the red vapours that predict the approaching aſcent of the Cinabar, the receiver containing the Butter muſt be removed, leſt the colour of the Butter ſhould be ſpoiled by thoſe ſulphureous vapours. Another receiver is uſually fitted on, without luting; in which a ſmall quantity of running Mercury is ſometimes found, when the operation is finiſhed.

There remains, at the bottom of the retort, a fixed, ſhining, cryſtalline, black maſs, which may be reduced to a Regulus by the common method.

Butter of Antimony may alſo be obtained from a mixture of Antimony with any of the other preparations of Mercury in which the Acid of Sea-ſalt is an ingredient; ſuch as ſweet

Sublimate, the Mercurial Panacea, and White Precipitate: but as none of theſe combinations contain ſo great a proportion of that Acid as is in the Corroſive Sublimate, the Butter obtained by their means is far from being ſo cauſtic and ſo fiery as that which riſes from a mixture of Antimony, or its Regulus, with Corroſive Sublimate.

Silver precipitated by the Acid of Sea-ſalt, and ready to be melted into a *Luna cornea*, being mixed with powdered Regulus of Antimony yields likewiſe a Butter of Antimony.

If you propoſe to make it by this means, you muſt mingle one part of the Regulus of Antimony in powder with two parts of the Precipitate; put this mixture into a glaſs retort of ſuch a ſize that it may fill but one half thereof; ſet it in a furnace; apply a receiver; begin with a gentle heat, which will make a clear liquor come over; and then increaſe your fire by degrees. White vapours will riſe and condenſe into a liquid Butter; and in the mean time there will be a ſlight ebullition in the receiver, attended with a little heat. Continue the fire till nothing more will come over; then let your veſſels cool and unlute them.

You will find in the receiver an Oil or Butter of Antimony, partly fluid and partly congealed, ſomewhat inclined to yellow, weighing an eighth part more than the Regulus of Antimony made uſe of.

The inſide of the retort will be carpeted over with ſmall white flowers, of a brilliant ſilver colour, and an acid taſte; and in the bottom of the retort will be found a hard, compact, ponderous maſs, difficult to break, yet falling of itſelf to a powder; its colour externally grey, white, and blueiſh; internally black, and ſhining much like Regulus of Antimony; having a ſaltiſh taſte on its ſurface, and weighing about a ſixteenth leſs than the Precipitate of Silver employed in the operation.

This experiment demonſtrates that the Acid of Sea-ſalt hath a greater affinity with Regulus of Antimony than with Silver.

The Butter of Antimony prepared by this method is ſomewhat leſs cauſtic than that made with Corroſive Sublimate. It is called the *Lunar Butter of Antimony*.

The effervescence that ariſes in the receiver is remarkable. Probably the Acid of Sea-ſalt, though reduced into vapours when it aſcends out of the retort, is not yet perfectly combined with the reguline part of the Antimony, which it nevertheleſs carries over with it, and the union is completed in the receiver; which occaſions the effervescence obſerved.

The little white ſilvery flowers, adhering to the inſide of the retort, are flowers of Regulus of Antimony, which ſublime towards the end of the diſtillation.

The compact maſs, found at the bottom of the retort, is no other than the Silver ſeparated from its Acid, and combined with a portion of the Regulus of Antimony. The colours and the ſaltiſh taſte of its ſurface are occaſioned by a remainder of the Marine Acid. This Silver is rendered brittle and eager by the union it hath contracted with ſome of the Regulus of Antimony.

It is eaſy to purify it, and reſtore its ductility, by ſeparating it from the Regulus of Antimony. There are ſeveral ways of doing this: one of the moſt expeditious is to flux it with Nitre, which burns and converts to a calx the ſemi-metal with which the Silver is adulterated.

PROCESS XII.

Butter of Antimony decompounded by means of Water only. The Pulvis Algaroth, *or* Mercurius Vitæ. *The Philoſophic Spirit of Vitriol.*

MELT with a gentle heat as much Butter of Antimony as you pleaſe. When it is melted, pour it into a large quantity of warm water. The water will immediately grow turbid, but whitiſh, and let fall a great quantity of white powder. When all the precipitate is ſettled, decant the water: pour on freſh warm water; and having thus edulcorated it by ſeveral ablutions, dry it, and you have the *Pulvis Algaroth*, or *Mercurius Vitæ*.

OBSERVATIONS.

In the preceding proceſſes we obſerved that the Marine Acid will not diſſolve the reguline part of Antimony, unleſs it be very highly concentrated, and more ſo than it can poſſibly be while in the form of a liquor. Of this the experiment before us is a further proof. Whilſt the Marine Acid is ſo perfectly dephlegmated, as it is in Corroſive Sublimate and Butter of Antimony, it remains combined with the reguline part of Antimony; but if this combination be diſſolved in water, the moment the Acid is weakened by the interpoſition of the particles of water, it becomes incapable of continuing united with the ſemi-metal which it had before

fore diſſolved; deſerts it, and lets it fall in the form of a white powder.

The *Pulvis Algaroth* is therefore no other than the reguline part of Antimony, attenuated and divided by the union it had contracted with the Acid of Sea-ſalt, and afterwards ſeparated from that Acid by the intervention of water alone. The proof is, that this powder retains none of the properties of the Butter of Antimony: it is neither ſo fuſible nor ſo volatile; on the contrary, it is capable of ſuſtaining a very ſtrong degree of fire, without ſubliming and without melting: it may be reduced to a Regulus: it hath not now the ſame cauſtic nature: it is only an emetic; which however is extremely violent, and on that account is never preſcribed by any prudent phyſician.

Another proof, that the Marine Acid is ſeparated from the Regulus of Antimony in the precipitation of the *Pulvis Algaroth*, is, that the water in which this precipitation is made becomes acid, or a ſort of weak Spirit of Salt. If it be evaporated, and concentrated by diſtillation, a very ſtrong acid liquor may be obtained from it. This Acid goes, very improperly, by the name of the *Philoſophic Spirit of Vitriol;* for it is rather a Spirit of Salt.

The *Pulvis Algaroth*, made with Butter of Antimony procured from the Regulus, is whiter than that made with Butter of Antimony procured from crude Antimony; probably becauſe the latter always retains ſome ſulphureous particles.

Butter of Antimony expoſed to the air attracts the moiſture thereof, and partly runs into a liquor; but, as faſt as this liquor is produced, it depoſites a white ſediment, which is an actual *Pulvis Algaroth.* This alſo is very agreeable to what we advanced touching the decompoſition of Butter of Antimony by the addition of water. The Butter attracts the moiſture of the air, becauſe the Acid it contains is exceedingly concentrated; and this moiſture produces the ſame effect as water purpoſely added.

PROCESS XIII.

Bezoar Mineral. The Bezoartic Spirit of Nitre.

MELT Butter of Antimony over warm aſhes, and put it into a phial or matraſs. Gradually pour on it good Spirit of Nitre, till the matter be entirely diſſolved.

This uſually requires as much Spirit of Nitre as there is Butter of Antimony. During the diſſolution fumes will riſe, which muſt be carefully avoided. Pour your ſolution, which will be clear and of a reddiſh colour, into a glaſs cucurbit, or a pan of ſtone-ware: ſet it in a ſand-bath, and evaporate to dryneſs with a moderate heat. There will be left a white maſs, weighing a fourth part leſs than the whole quantity uſed, both of the Butter and the Spirit of Nitre. Let it cool, and again pour on it as much Spirit of Nitre as you uſed the firſt time. Place the veſſel again in the ſand-bath, and evaporate the moiſture as before. You will have a white maſs that hath neither gained nor loſt in weight. On this pour, for the third time, the ſame quantity of Spirit of Nitre as you did the firſt time. Again evaporate the moiſture to perfect dryneſs: then increaſe your fire, and calcine the matter for half an hour. You will have a dry, friable, light, white matter, of an agreeable acid taſte; which will fall into a coarſe powder, and muſt be kept in a phial carefully ſtopt. This is *Bezoar Mineral:* it is neither cauſtic nor emetic, and has only a ſudorific virtue. It obtained the name it bears, becauſe, like the animal Bezoar, it was imagined to have the property of reſiſting poiſon.

OBSERVATIONS.

It is not ſurpriſing that the Nitrous Acid poured on Butter of Antimony ſhould diſſolve it, and unite with it: for with the Marine Acid, which makes a part of this combination, it forms an *aqua regis*, which we know is the true ſolvent of the reguline part of Antimony. But in this diſſolution, and the changes it produces, there are ſome things very remarkable and worthy of attention. 1. The Nitrous Acid, by uniting with the Butter of Antimony, deprives it of its property of riſing with a very gentle heat, and makes it much more fixed: it can now be dried, and ſuffer all its moiſture to be evaporated; which is not to be done with pure Butter of Antimony: for that, being expoſed to a certain degree of heat, inſtead of letting go its moiſture and remaining dry, riſes wholly, without the leaſt appearance of any ſeparation of parts.

2. The Butter of Antimony, which, before its combination with the Nitrous Acid, is a moſt violent Cauſtic and Corroſive, becomes ſo mild after it, that it may not only be taken internally without danger, but hath ſcarce any ſenſible operation.

The following conſiderations will lead us to a reaſonable explanation of theſe phenomena. 1. The Nitrous Acid, when combined with metallic ſubſtances, doth not communicate to them the ſame volatility as they acquire from the Marine Acid. Hence it follows, that, if the Nitrous Acid be added to any combination of a metallic ſubſtance with the Marine Acid, this new compound will be rendered leſs volatile, and conſequently more able, without riſing in vapours, to bear a degree of heat ſufficient to carry off part of its Acid. This is the caſe with Butter of Antimony, after Spirit of Nitre is mixed with it; eſpecially conſidering, 2. That the Nitrous Acid cannot unite with the reguline part of the Butter of Antimony without weakening the connection between it and the Marine Acid; whence it follows, that the combination of the Nitrous Acid further facilitates the ſeparation of the Marine Acid from the Regulus. Now as ſoon as the Marine Acid quits the reguline part, that part becomes more fixed, and conſequently more capable of enduring the degree of heat requiſite to diſcharge all the adhering Acid; and not only the Marine, but even the Nitrous alſo. It is not therefore ſurprizing that, after the Antimony which remains combined with the Nitrous Acid is dried, it ſhould not poſſeſs that corroſive power which it derives only from the Acids wherewith it is armed. In order to free it more perfectly from all Acid, we order the fire to be increaſed after the third deſiccation; and the remainder of the Butter of Antimony to be calcined for a full half-hour longer.

That the Marine Acid is ſeparated from the reguline part of the Butter of Antimony, by the deſiccations it undergoes in converting it into Bezoar, is proved by this, that, when theſe deſiccations are performed in cloſe veſſels, the liquor drawn off is a true *aqua regis*, known by the name of the *Bezoartic Spirit of Nitre.*

It remains to be conſidered why the Bezoar mineral, though freed from all acid, is not emetic; while the *Pulvis Algaroth*, which is likewiſe the reguline part of the Butter of Antimony deprived of its Acid, is ſuch a violent emetic, and even to be dreaded for its remaining cauſticity.

In order to diſcover the reaſon of this difference, it is proper to obſerve that, when we ſay Bezoar mineral and the *Pulvis Algaroth* contain no Acid, we muſt not be underſtood in too ſtrict a ſenſe: on the contrary, there is reaſon to think that a certain quantity of Acid ſtill remains in each of them; which however is ſcarce worth notice, in compariſon of the quantity each contained at firſt. This being allowed, it will not be hard to find the difference between theſe two preparations of Antimony. The *Pulvis Algaroth* is deprived of its Acid by the addition of water alone, which only carries off all the looſe Acid it can take up, without making any change in the nature of that which continues in combination with the reguline part. Now, as the Marine Acid is not intimately united with the reguline part in Butter of Antimony; as it ſtill retains ſome of its properties, ſuch as attracting the moiſture of the air, giving manifeſt tokens of its Acid nature, &c.; and as the corroſive quality of this compound depends on this laſt in particular; the ſmall portion of Acid left in the *Pulvis Algaroth* will in ſome degree preſerve its former character: and hence comes the effect of this powder, which ſtill retains a little of the corroſive quality that belonged to the Butter of Antimony.

But this is not the caſe with the ſmall remainder of Acid, which poſſibly ſtill continues united with the Bezoar mineral prepared as here directed. This compound hath been expoſed to a fire ſufficient, not only to dry it, but even to calcine it. Now fire is capable of producing great changes in the texture of bodies. It muſt have forced off from the Bezoar all the Acid that was not intimately combined with it; and that part which it could not drive off, becauſe of its obſtinate adheſion, it muſt have further united and combined more cloſely with the metallic earth: for we ſee that fire greatly promotes the action of ſolvents on the matters with which they are united.

With regard to the properly emetic quality of the *Pulvis Algaroth*, it cannot be imputed to the combination of any Acid with that powder; ſince we ſee that the moſt powerfully emetic preparations of Antimony, *viz.* its Regulus and Glaſs, contain no Acid: it muſt therefore be attributed to ſome cauſe different from that on which its corroſive quality depends. This cauſe we ſhall eaſily find by attending to the different manners in which the Marine Acid, when alone and in *aqua regia*, operates on the reguline part of Antimony.

The Marine Acid alone diſſolves the Regulus of Antimony, but with great difficulty; nor doth it effect a complete diſſolution thereof, as is evident from what hath been already ſaid: whereas the Marine Acid, combined with the Nitrous Acid, and therewith forming an *aqua regis*, as in the preparation of Bezoar, diſſolves the reguline part of Antimony completely and radically. Now, it is certain that, the more efficaciouſly Acids operate on metallic ſubſtances, the more of their phlogiſton do they deſtroy; and we cannot but recollect that the preparations of Antimony are ſo much the leſs emetic the leſs phlogiſton they contain, or the further they recede from the nature of a Regulus, and the nearer they approach to that of Diaphoretic Antimony: conſequently it is plain how Bezoar mineral, which is a ſort of calx of Antimony entirely deprived of its phlogiſton by the intimate diſſolution thereof made by the Acids of the *aqua regis*, may be in no degree emetic; while the *Pulvis Algaroth*, being a true Regulus of Antimony, on which the Marine Acid hath operated but very ſuperficially, and which ſtill contains a great deal of phlogiſton, is a moſt violent emetic.

PROCESS XIV.

Flowers of Antimony.

TAKE an unglazed earthen pot, having an aperture in its ſide, with a ſtopple to ſhut it cloſe. Set this pot in a furnace, the cavity whereof it may fit as exactly as poſſible; and fill up with lute the ſpace, if any, left between the veſſel and the furnace. Over this veſſel fix three aludels, with a blind-head at the top; and light a fire in the furnace under the pot.

When the bottom of the pot is thoroughly red, throw into the lateral aperture a ſmall ſpoonful of powdered Antimony. Stir the matter immediately with an iron ſpatula made a little bending, in order to ſpread it over the bottom of the veſſel, and then ſtop the hole. The flowers will riſe and adhere to the inſides of the aludels. Keep up the fire ſo that the bottom of the pot may always continue red; and, when nothing more ſublimes, put in a like quantity of Antimony, and operate as before. In this manner go on ſubliming your Antimony, till you have as many flowers as you want. Then let the fire go out; and when the veſſels are cold unlute them. You will find flowers adhering all round the inſides of the aludels and the head, which you may collect with a feather.

OBSERVATIONS.

ANTIMONY is a volatile mineral, capable of being ſublimed into flowers; but this cannot be effected without occaſioning a notable change in its parts. The reguline and the ſulphureous parts are not united ſo intimately, or in the ſame proportion, in the flowers as in the Antimony itſelf; and accordingly we find theſe flowers have a ſtrong emetic quality, which Antimony hath not. They are of divers colours; which probably ariſes from their containing more or leſs Sulphur. Three or four aludels are placed one over another, not only with a view to provide a greater ſurface, to which the flowers may adhere, but alſo to give them room enough to circulate, without which they might burſt the veſſels.

If you introduce the noſle of a pair of bellows into the pot that contains the Antimony, and blow upon it, the ſublimation of the flowers will be much ſooner effected. This is a general rule with regard to all matters that are to be ſublimed or evaporated; the reaſon of which we have already given.

It is proper that no interval be left between the furnace and the pot containing the Antimony, leſt the heat ſhould be thereby communicated to the aludels, on which the flowers faſten beſt when they are cold.

After the operation, there remains at the bottom of the pot a portion of Antimony half calcined; which being pulverized, and thoroughly calcined till it emit no fume, may be employed to make the Glaſs of Antimony.

PROCESS XV.

Regulus of Antimony converted into Flowers.

PULVERIZE your Regulus of Antimony: put the powder into an unglazed earthen pot: three or four fingers breadth above the powder, fit into the pot a little cover, made of the ſame earth, and having a ſmall hole in its middle, ſo that it may with eaſe be placed in the pot, and taken out when there is occaſion: cover the mouth of the pot with a common lid; ſet it in a furnace, and kindle a fire under it ſufficient to make the bottom of the pot red, and to melt the Regulus. When it hath been thus kept in fuſion for about an hour, let the fire go out, and the whole cool. Then remove the two covers. You will find adhering to the ſurface of the Regulus, which will be in a maſs at the bottom of the pot, white flowers reſembling ſnow, intermixed with beautiful, brilliant, ſilver-coloured needles. Take them out, and you will find them make about one part in ſixty-two of the whole Regulus employed.

Put the covers again in their places, and proceed in the ſame manner as before; when the veſſels are cold you will find half as many more flowers as you got the firſt time.

Proceed thus till you have converted all your Regulus into flowers. This will require a conſiderable number of ſublimations, which, as you advance, will always yield you a greater portion of flowers; reſpect, however, being had to the quantity of Regulus remaining in the pot.

OBSERVATIONS.

We muſt here repeat what we ſaid juſt before, in our obſervations on the preceding proceſs; *viz.* that Regulus of Antimony is capable of being wholly elevated and ſublimed by the action of fire; but that it muſt at the ſame time undergo a conſiderable change and alteration. Theſe flowers of Regulus of Antimony are very different from every other Antimonial preparation. They reſemble the Pearly Matter in this, that they cannot be reduced to a Regulus by any means whatever: but they differ from it, 1. in that they are not fixed; for, when melted by fire, they fly wholly away in vapours: 2. in that they are capable of being diſſolved by *aqua regis*, much in the ſame manner as the Regulus; whereas the Pearly Matter is known to be indiſſoluble by any Acid.

As ſoon as Regulus of Antimony is in fuſion, it begins to ſublime into flowers; ſo that it is needleſs to apply a greater degree of heat than is juſt ſufficient to melt it.

A pan of ſome width is preferable to a crucible for this operation; becauſe the upper ſurface of the Regulus melted therein is larger, and, the larger that ſurface is, the more conſiderable is the quantity ſublimed from it.

The two covers which are applied within and over the pot are deſigned to check, as much as poſſible, the diſſipation of the melted Regulus; yet without abſolutely excluding the free acceſs of the air, the concourſe of which is uſeful in all metallic ſublimations. Notwithſtanding theſe precautions, it is impoſſible to prevent the eſcape of ſome of the Regulus, in vapours that cannot be confined. Somewhat leſs than three fourths of the Regulus made uſe of is nearly the yield in flowers: the reſt evaporates through the interſtices left by the covers, which muſt not be luted for the reaſon juſt aſſigned.

CHAP. II.

Of BISMUTH.

PROCESS I.

To extract Biſmuth from its Ore.

BREAK the ore of Biſmuth into ſmall pieces, and therewith fill a crucible either of earth or iron. Set the crucible in a furnace, and light ſuch a fire that the bits of ore may become moderately red. Stir the ore from time to time, and, if you perceive it crackle and fly, keep the crucible covered. At the bottom you will find a button of Biſmuth.

OBSERVATIONS.

THE extraction of Biſmuth from its ore requires nothing but ſimple fuſion, without the addition of any inflammable matter, becauſe it is naturally poſſeſſed of its metalline form. Nor does it require any flux; becauſe it is very fuſible: which allows us to melt it, and collect it in a maſs, without the neceſſity of fuſing likewiſe the earthy and ſtony matters in which it is lodged. Theſe matters remain in their firſt ſtate; and the melted Biſmuth deſcends by its gravity to the bottom of the crucible. No greater degree of heat muſt be applied, on this occaſion, than is neceſſary to melt the ſemi-metal: for, as it is volatile, part of it would be diſſipated; ſo that much leſs thereof would be obtained, if the fire were made too ſtrong, and ſo much the leſs as another portion thereof would be converted into a calx. For the ſame reaſon, the crucible muſt be taken out of the furnace as ſoon as you perceive that all the Biſmuth contained in the ore is melted, and that the button doth not increaſe.

The ore of Biſmuth may alſo be treated like the ores of Lead and Tin; that is, it may be reduced into a fine powder, mixed with the black flux, a little Borax, and Sea-ſalt; put into a cloſe crucible, and fuſed in a melting furnace. In that caſe you will find a button of Regulus covered with ſcoria. By this method rather more Biſmuth is obtained;

and it is beſt to make uſe of it when the ore is poor, becauſe, in ſuch a caſe, none at all would be obtained by the other proceſs. But here care muſt be taken to apply at once the degree of fire neceſſary to melt the mixture: for, if it remain long in the fire, much Biſmuth will be loſt, on account of the great volatility of this ſemi-metal, and the facility with which it turns to a calx.

Biſmuth is pretty frequently found pure in its earthy and ſtony matrices; and when mineralized it is uſually ſo by Arſenic, which, being ſtill more volatile, flies off in vapours while the ore is melting, provided it be but in a ſmall quantity: if there be much of it, and the ore be ſmelted by fuſing it with the black flux, the Arſenic alſo is reduced to a Regulus, unites more intimately with the Biſmuth, becomes a little more fixed by that union, and increaſes the quantity of the ſemi-metallic maſs found after the fuſion.

Though Biſmuth be not uſually mineralized by Sulphur, that is not becauſe it is incapable of uniting therewith; for, if equal parts of Biſmuth and Sulphur be melted together, after the fuſion the Biſmuth will be found increaſed near an eighth part, and formed into a maſs diſpoſed in needles much like Antimony.

When we come to treat of the ore of Arſenic, we ſhall have occaſion to ſay a good deal more concerning Biſmuth and its ore; becauſe theſe minerals reſemble each other very much.

Mr. Geoffroy, ſon of the Academician, hath ſhewn in a Memoir read before the Academy of Sciences, that there is a great reſemblance between Biſmuth and Lead. That Memoir, which contains only the beginning of Mr. Geoffroy's courſe of experiments, proves that the author ſupports with dignity the glory of his name. It is there demonſtrated, by a very great number of experiments, that fire produces the ſame effects on Biſmuth as on Lead. This ſemi-metal is converted into a calx, into litharge, and into glaſs, as Lead is; and theſe productions have the ſame properties as the preparations of Lead made with the ſame degree of fire. Biſmuth is capable of vitrifying all the imperfect metals, and of carrying them off through the pores of the crucible. So that Gold and Silver may be purified and cupelled by its means, as well as with Lead. You may on this occaſion turn to what we have ſaid concerning Lead.

PROCESS II.

Biſmuth diſſolved by Acids. Magiſtery of Biſmuth. Sympathetic Ink.

INTO a matraſs put Biſmuth broken into little bits: pour on it, by little and little, twice as much *aqua fortis*. This Acid will attack the ſemi-metal briſkly, and diſſolve it entirely, with heat, effervescence, vapours, and puffing up. The ſolution will be clear and limpid.

OBSERVATIONS.

OF all Acids the Nitrous is that which beſt diſſolves Biſmuth. It is not neceſſary, on this occaſion, to place the phial, in which the diſſolution is performed, on a ſand-heat, as in moſt other metallic diſſolutions: on the contrary, care muſt be taken not to pour on all the *aqua fortis* at once; becauſe it operates with ſo much activity that the mixture will heave up and run over the veſſel.

The bare addition of water is ſufficient to precipitate the ſolution of Biſmuth. If this ſolution be mixed with a very large proportion of water, the liquor grows turbid, appears milky, and depoſites a precipitate of a very beautiful white. This is that white which the ladies uſe at their toilets.

Water produces this precipitation by weakening the Acid; which probably is incapable of keeping the Biſmuth diſſolved, unleſs it have a certain degree of ſtrength.

If you would have a Magiſtery of Biſmuth beautifully white, you muſt perform the diſſolution with an *aqua fortis* that is not tainted with any mixture of the Vitriolic Acid; for this gives the precipitate a dirty white colour, inclining to grey. Several authors adviſe the uſe of a ſolution of Sea-ſalt, inſtead of pure water, for precipitating the Biſmuth, imagining that this Salt will effect a precipitation here as it does in the caſes of Silver and Lead. But Mr. Pott, a German Chymiſt, who hath publiſhed a long diſſertation on Biſmuth, pretends, on the contrary, that neither Sea-ſalt, nor its Acid, is capable of precipitating this ſemi-metal; and that when a precipitation takes place on mixing them with our ſolution, it is brought about only by means of the water in which thoſe ſubſtances are diffuſed.

Biſmuth may alſo be precipitated by the means of Fixed or Volatile Alkalis; but the precipitate is not of ſo fine a white as when procured by the means of pure water only.

If a greater quantity of *aqua fortis*, than that preſcribed in the proceſs, be made uſe of to diſſolve the Biſmuth, a great deal more water will alſo be required to precipitate the Magiſtery; becauſe there will be much more Acid to weaken. This white ought to be well waſhed, in order to free it from any remainder of acidity; and it ſhould be kept in a bottle well ſtopped; becauſe the acceſs of the air makes it turn brown, and if any of the Acid be left it will turn it yellow.

A ſolution of Biſmuth prepared with the proper quantity of *aqua fortis*, that is, with two parts of the Acid to one of the ſemi-metal, concretes into little cryſtals almoſt as ſoon as made.

Aqua fortis not only acts on Biſmuth when ſeparated from its ore, and reduced to a Regulus, but attacks it even in its ore, and likewiſe diſſolves at the ſame time ſome portion of the ore itſelf. With this ſolution of the ore of Biſmuth Mr. Hellot makes a very curious Sympathetic Ink, differing from all that were known before.

Mr. Hellot prepares the liquor in the following manner: " He bruiſes the ore of Biſmuth to a coarſe powder. On " two ounces of this powder he pours a mixture of five " ounces of common water with five ounces of *aqua fortis*. " He does not heat the veſſel till the firſt ebullitions are " over. He then ſets it in a gentle ſand-heat, and lets it " digeſt there till he ſees no more air-bubbles riſe. When " none appear in this heat, he increaſes it ſo as to make the " ſolvent boil ſlightly for a full quarter of an hour. It takes " up a tincture nearly of the colour of brown beer. The " ore that gives the *aqua fortis* this colour is the beſt. He " then lets the ſolution cool, laying the matraſs on its ſide, " that he may decant the liquor more conveniently when all " is precipitated that is not taken up by the ſolvent.

" The ſecond veſſel, into which the liquor is firſt decant- " ed, he alſo lays declining, that a new precipitation of the " undiſſolved matters may be obtained; after which he " pours the liquor into a third veſſel. This liquor muſt not " be filtered, if you would have the reſt of the proceſs ſuc- " ceed perfectly; becauſe the *aqua fortis* would diſſolve " ſome of the paper, and that would ſpoil the colour of " your paper.

" When this ſolution, which Mr. Hellot calls the *Impreg-* " *nation*, is thoroughly clarified by being decanted three or

" four times, he puts it into a glaſs baſon with two ounces " of very pure Sea-ſalt. The fine white ſalt made by the " ſun ſucceeded beſt with Mr. Hellot. If that cannot be " had, common bay-ſalt, purified by ſolution, filtration, and " cryſtallization, may be uſed inſtead of it. But as it is " rare to meet with any of the ſort that is not a little taint- " ed with iron, the white bay-ſalt is to be preferred. The " glaſs baſon he ſets in a gentle ſand-heat, and keeps it " there till the mixture be reduced by evaporation to an al- " moſt dry ſaline maſs.

" If you deſire to ſave the *aqua regis*, the impregnation " muſt be put into a retort, and diſtilled with the gentle " heat of a ſand-bath. But there is an inconveniency, as " Mr. Hellot obſerves, in employing a retort; which is, that, " as the ſaline maſs cannot be ſtirred while it coagulates in " the retort, it is reduced to a compact cake of coloured " Salt, which preſents but one ſingle ſurface to the water in " which it muſt be diſſolved; ſo that the diſſolution thereof " takes up ſometimes no leſs than five or ſix days. In the " baſon, on the contrary, the ſaline maſs is eaſily brought " to a granulated Salt, by ſtirring it with a glaſs rod; and, " when thus granulated, it has a great deal more ſurface; it " diſſolves more eaſily, and yields its tincture to water in " four hours time. Indeed one is more expoſed to the " vapours of the ſolvent, which would be dangerous, if the " operation were to be often performed, without proper pre- " cautions.

" When the baſon, or little veſſel, containing the mixture " of the Impregnation and Sea-ſalt is heated, the liquor, " which was of an orange-coloured red, becomes a crimſon " red; and, when all the phlegm of the ſolvent is evaporat- " ed, it acquires a beautiful emerald colour. By degrees it " thickens, and acquires the colour of a maſs of Verdegris. " It muſt then be carefully ſtirred with the glaſs rod, in or- " der to granulate the Salt, which muſt not be kept over the " fire till it be perfectly dry; becauſe you run a riſk of loſ- " ing irrecoverably the colour you are ſeeking. You may be " ſure you have loſt it, if by too much heat the Salt that " was of a green colour become of a dirty yellow. If it be " once brought to this ſtate, it will continue without chang- " ing when cold: but if care be taken to remove it from " the fire while it is ſtill green, you will ſee it gradually grow " pale, and become of a beautiful roſe colour as it cools.

" Mr. Hellot removes it from this veſſel, and throws it " into another containing diſtilled rain water: and this ſe-

" cond veſſel he keeps in gentle digeſtion till he obſerves " that the powder which falls to the bottom is perfectly " white. If, after three or four hours digeſting, this powder ſtill continues tinged with a roſe colour, it is a proof " that water enough was not added to diſſolve all the Salt " impregnated with the tincture of the ſolution. In this " caſe, the firſt tinged liquor muſt be poured off, and freſh " water added, in proportion to the quantity of tinged Salt, " that is ſuppoſed to remain mixed with the precipitate.

" When the ore is pure, and doth not contain a great " deal of fuſible ſtone, commonly called *Fluor* or *Quartz*, " an ounce of it generally yields tincture enough for eight " or nine ounces of water, and the liquor is of a beautiful " colour like that of the lilach or pipe-tree bloſſom. In order " to prove the effect of this tincture, you muſt write with " this lilach-coloured liquor on good well-gummed paper, " that does not ſink: or you may uſe it to ſhade the leaves " of ſome tree or plant, having firſt drawn the outlines " thereof lightly, with China-ink or with a black-lead pencil. Let this coloured drawing, or writing, dry in a " warm air. You will perceive no colour while it is cold; " but if it be gently warmed before the fire, you will ſee " the writing, or the drawing, gradually acquire a blue or " greeniſh-blue colour, which is viſible as long as the paper " continues a little warm, and diſappears entirely when it " cools."

The ſingularity of this ſympathetic ink conſiſts in its property of diſappearing entirely and becoming inviſible, though it be not touched with any thing whatever: and this diſtinguiſhes it from all others; which, when once rendered viſible by the application of proper means, do not again diſappear, or at leaſt not without touching the ſtrokes on the paper with ſome other liquor.

Mr. Hellot made a vaſt variety of experiments on this ſubject, and gave his ſympathetic ink ſucceſſively the properties of all others that are known.

It follows from Mr. Hellot's experiments, that it is the Acid of Sea-ſalt which makes this ſaline *magma* of a green colour while it is hot: that without this Acid the ſaline matter continues red; and that the ſolution of Biſmuth-ore in *aqua fortis* may therefore ſerve as a touch-ſtone, to diſcover whether or no any unknown Salt under examination contains Sea-ſalt, or a portion of the Marine Acid.

He alſo proves, in the Memoirs he hath given in on this ſubject, that the Nitrous Acid is the true ſolvent of thoſe ores of Biſmuth which contain moreover Smalt and Arſenic. That Acid diſſolves all the metallic and colouring matters contained in thoſe ores, ſparing nothing but the ſulphureous and arſenical portion, the greateſt part of which remains precipitated; and from this colouring matter the ſympathetic ink derives its virtue.

Under the head of Arſenic we ſhall ſpeak more amply of this matter in Cobalt, or the ore of Arſenic, that gives a blue colour to the ſand with which it is vitrified.

The Vitriolic Acid does not, properly ſpeaking, diſſolve Biſmuth. If to one part and an half of this ſemi-metal you add one part of Oil of Vitriol; diſtil the whole to dryneſs; and then lixiviate with water what remains in the retort; the liquor you obtained by this means will be of a reddiſh yellow colour, but will let nothing fall when mixed with an Alkali: and this ſhews that the Vitriolic Acid acts only upon the inflammable part of Biſmuth, and doth not diſſolve its metallic earth.

It diſſolves the ore of Biſmuth more perceptibly than Biſmuth itſelf; becauſe the ore contains, beſides the reguline part, an arſenical matter, and a coloured matter, over which perhaps it hath more power.

The Acid of Sea-ſalt attacks and diſſolves Biſmuth in ſome ſmall meaſure, but ſlowly and with difficulty. That this Acid diſſolves a portion of our ſemi-metal may be proved, by mixing a Fixed or Volatile Alkali with Spirit of Salt in which Biſmuth hath lain ſome time digeſting; for then a precipitate falls.

But, though the Marine Acid be capable of diſſolving Biſmuth, it doth not follow that it hath a greater affinity than the Nitrous Acid with this metallic ſubſtance, as ſome Chymiſts have thought; who imagined that, in the precipitation of the Magiſtery of Biſmuth by a ſolution of Sea-ſalt, the Acid of that Salt quits its baſis to unite with the Biſmuth which it precipitates, as is the caſe in the precipitations of Lead and of Silver by the ſame Salt, and that it forms, on this occaſion, a *Biſmuthum corneum*.

On this ſubject Mr. Pott obſerved, 1. that, when only a ſmall quantity of the ſolution of Sea-ſalt is mixed with the ſolution of Biſmuth in the Nitrous Acid, no precipitate is formed: now it is certain that when the ſmalleſt quantity whatever of Sea-ſalt is mixed with the ſolution either of Lead or of Silver, a precipitate is immediately depoſited, in a quantity proportioned to that of the Salt uſed.

2. Mr. Pott, having examined the precipitate of Biſmuth thrown down by a ſolution of Sea-ſalt, found it not to have the properties of a metallic ſubſtance rendered horny: on the contrary, that precipitate being expoſed to a very violent fire appeared refractory, and could not be melted.

CHAP. III.

Of ZINC.

PROCESS I.

To extract Zinc from its Ore, or Calamine.

TAKE eight parts of Calamine reduced to a powder; mix this powder accurately with one part of fine charcoal-duſt, previouſly calcined in a crucible to free it from all moiſture: put this mixture into a ſtone retort coated with lute, leaving a third part of it empty: ſet your retort in a reverberatory furnace, capable of giving a very fierce heat. To the retort apply a receiver, with a little water in it. Kindle the fire, and raiſe it by degrees till the heat be ſtrong enough to melt Copper. With this degree of fire the Zinc being metallized will ſeparate from the mixture, and ſublime into the neck of the retort, in the form of metallic drops. Break the retort when it is cold, and collect the Zinc.

OBSERVATIONS.

THE proceſs here given for ſmelting Zinc out of Calamine is taken from the Memoirs of the Academy of Sciences at Berlin. The author of it is Mr. Marggraff, a ſkilful Chymiſt, whom we have already had occaſion to mention under the article of Phoſphorus.

Till this proceſs was publiſhed, we knew no method of obtaining pure Zinc directly from the *Lapis Calaminaris.*

Moſt of the Zinc we have comes from an ore of difficult fuſion that is worked at Goſlar, and yields, at one and the ſame time, Lead, Zinc, and another metallic matter called *Cad-*

mia Fornacum, which alſo contains much Zinc, as we ſhall afterwards ſee.

The furnace uſed for ſmelting this ore is cloſed on its fore-ſide with thin plates or tables of ſtone, not above an inch thick. This ſtone is greyiſh, and bears a violent fire.

In this furnace the ore is melted amidſt charcoal, by the help of bellows. Each melting takes twelve hours, during which time the Zinc flowing with the Lead is reſolved into flowers and vapours, great part of which adheres to the ſides of the furnace in the form of a very hard cruſt of earth. The workmen take care to remove this cruſt from time to time; for it would otherwiſe grow ſo thick at laſt as to leſſen the cavity of the furnace very conſiderably.

There adheres moreover to the fore-part of the furnace, which is formed, as we ſaid before, of thin plates of ſtone, a metallic matter, which is the Zinc, and is carefully collected at the end of each melting, by removing from this part all the live coals. A quantity of ſmall coal is laid unlighted at the bottom; and on this ſmall coal, by ſtriking the ſtone plates gently with a hammer, the Zinc is made to fall out of the other matter, known by the Latin name of *Cadmia Fornacum*, among which it appears fixed in a radiated form. To this other matter we may properly enough give the name of *Furnace-Calamine*. The Zinc falls in the form of a melted metal, all on fire, and in a bright flame. It would ſoon be entirely burnt and reduced to flowers, as we ſhall ſee, if it were not extinguiſhed, and eaſily cooled and fixed, by being hid under the unlighted ſmall-coal placed below on purpoſe to receive it.

The Zinc adheres to the fore-part of the furnace preferably to any other, becauſe that being the thinneſt is therefore the cooleſt: and, in order further to promote its fixing on this part, they take care to keep the thin ſtone plates cool during the operation, by throwing water on them.

Hence it appears, that Zinc is not extracted from its ore by fuſion and the precipitation of a Regulus, like other metallic ſubſtances. This is owing to the great volatility of our ſemi-metal, which cannot, without ſubliming, bear the degree of fire neceſſary to melt its ore. It is at the ſame time ſo combuſtible, that a great part of it riſes in flowers which have not the metalline form.

Mr. Marggraff provides againſt theſe inconveniences by working the ore of Zinc in cloſe veſſels. By this means he prevents the Zinc from taking fire, and being converted into flowers; ſo that it ſublimes in its metalline form. The water

ter in the recipient ſerves to receive and cool the drops of Zinc that may be forced quite over the helm. As the operation requires a moſt violent fire, theſe drops muſt needs iſſue exceeding hot, and, without this precaution, break the recipient.

Mr. Marggraff by the ſame proceſs extracted Zinc out of the Furnace-Calamine procured from ores containing Zinc; from Tutty, which is a ſort of furnace-calamine; from the flowers and from the calx of Zinc; and from the precipitate of White Vitriol; all of them matters known to be Zinc, that wanted nothing but the phlogiſton to give it a ſemi-metalline form, and from which nevertheleſs no body could ever before him procure any Zinc.

Mr. Marggraff obſerves, that the Zinc obtained by his proceſs bears being flatted under the hammer into pretty thin plates; which the common Zinc will not do. The cauſe of this probably is, that the Zinc obtained by his method is more intimately combined with the phlogiſton, and contains a greater quantity thereof, than that which is procured in the ordinary way.

PROCESS II.

To ſublime Zinc into Flowers.

TAKE a very deep, large crucible: place it in a furnace, ſo that it may ſtand inclining in an angle of forty-five degrees nearly. Throw ſome Zinc into it, and kindle a fire in the furnace ſomewhat ſtronger than would be neceſſary to keep Lead in fuſion. The Zinc will melt. Stir it with an iron wire, and there will appear on its ſurface a very bright white flame: two inches above this flame a thick ſmoke will be formed, and with this ſmoke exceeding white Flowers will riſe, and remain ſome time adhering to the ſides of the crucible, in the form of a very fine light down. When the flame ſlackens, ſtir your melted matter again with the iron wire: you will ſee the flame renewed, and the flowers begin again to appear in greater abundance. Go on thus till you obſerve that the matter will not flame, nor any more Flowers riſe.

OBSERVATIONS.

ZINC takes fire very eaſily as ſoon as it is affected by a certain degree of heat; which proves, that in the compoſition of this ſemi-metal there is very much phlogiſton, united but ſlightly with its metallic earth. The Flowers into which Zinc reſolves, during its combuſtion, are of a perfectly ſingular nature, and differ greatly from all the other productions obtainable out of metallic ſubſtances.

They may be conſidered as the very calx of Zinc, or its metallic earth robbed of its phlogiſton, and ſublimed during the combuſtion of this ſemi-metal, being probably carried up by the phlogiſton in flying off. For theſe Flowers, when once ſublimed, are afterwards exceedingly fixed: they ſuſtain the greateſt violence of fire without riſing, and are converted by it into a ſort of glaſs.

None of the methods hitherto employed, for reſtoring to the Flowers of Zinc their metalline form, have ever ſucceeded. When treated like other metalline calces in a crucible, with every kind of inflammable matter, and different ſorts of reducing fluxes, they never can be re-metalized: they only melt with the flux, and produce a kind of Glaſs.

Mr. Marggraff indeed, as mentioned before, obtained Zinc from theſe Flowers, by treating them as he did Calamine in a retort with charcoal-duſt: but as the Flowers often carry up with them little particles of undecompoſed Zinc, there ſtill remains ſome doubt concerning the reduction of theſe Flowers, even by this method.

If the crucible, into which you put the Zinc to be converted into Flowers, inſtead of being left open, as directed, be covered with another crucible inverted, the two veſſels luted together, placed in a melting furnace, and a ſtrong fire immediately kindled and kept up for about half an hour; you will find, when the veſſels are cold, that all the Zinc hath left the lower crucible, and is ſublimed into the upper one, in its metalline form, without ſuffering any decompoſition. This experiment proves, that Zinc, to be converted into Flowers, muſt neceſſarily be ſet on fire and burnt. As it cannot burn in cloſe veſſels, any more than other combuſtible bodies, and as it is volatile, it ſublimes without ſuffering any decompoſition. Regulus of Antimony and Biſmuth may be ſublimed in the ſame manner; but not ſo eaſily as Zinc, which is ſtill more volatile than thoſe other ſemi-metals.

It is neceſſary to ſtir the Zinc in fuſion from time to time with an iron wire, when you intend to convert it into Flowers: for there forms on its ſurface a grey cruſt that obſtructs its deflagration, and beneath which it is gradually converted into a clotted calx. In order, therefore, to promote the riſing of the flowers, care muſt be taken to break this cruſt, as oft as it begins to form. On this there immediately appears a very bright white flame: two inches above the flame is ſeen a thick ſmoke, and with this ſmoke very white Flowers riſe, that continue ſome time adhering to the inſide of the crucible, in the form of a fine down.

M. Malouin, who, in ſundry Memoirs on Zinc, hath endeavoured to diſcover what reſemblance there is between this ſemi-metal and Tin, tried to calcine Zinc in the ſame manner as Tin; but found it ſomewhat more difficult. Zinc, while it is not in fuſion, doth not calcine; but it begins to turn to a calx the moment it begins to melt. M. Malouin, having repeated the fuſion of Zinc a great number of times, by that means collected at laſt a quantity of the calx of this ſemi-metal, reſembling other metalline calces. This calx of Zinc he melted in a crucible with animal fat; whereby the calx was remetallized, and reduced to Zinc. There is great reaſon to believe that the calx of Zinc made by this method is not ſo much burnt as the Flowers, and that it ſtill contains a portion of phlogiſton.

PROCESS III.

To combine Zinc with Copper. Braſs. Prince's Metal, &c.

POUND one part and an half of Calamine, and an equal quantity of charcoal: mingle theſe two powders together, and moiſten them with a little water. Put this mixture into a large crucible, or ſome other earthen veſſel that will bear a melting heat. Amongſt and over this mixture put one part of very pure Copper in thin plates, and then put freſh charcoal-duſt over all: cover the crucible; ſet it in a melting furnace; put coals all round it, and let them kindle gradually. Raiſe the fire ſo as to make the crucible very red-hot. When you obſerve that the flame hath acquired a purple or bluiſh-green colour, uncover the crucible, and dip into it an iron wire, to examine whether or no the copper be in fuſion under the charcoal-duſt. If you find it is, moderate the force of the fire a little, and let your crucible remain in the furnace for a few minutes. Then take it out and let it cool: you will find your Copper of a gold colour, increaſed in weight a fourth, or perhaps a third part, and yet very malleable.

OBSER-

OBSERVATIONS.

THE *Lapis Calaminaris* is not the only ſubſtance with which Copper may be converted into braſs: all other ores containing Zinc, the Furnace-Calamine that ſublimes where ſuch ores are worked, Tutty, Zinc in ſubſtance, may be ſubſtituted for it, and, like it, will make very fine Braſs; but, in order to ſucceed, ſundry precautions are neceſſary which we ſhall now lay before you.

This proceſs is a ſort of cementation: for the Calamine doth not melt; only the Zinc is converted into vapours, and then combines with the Copper. On this the ſucceſs of the operation partly depends, as it is the means of the Copper's preſerving its purity and malleability; becauſe the other metallic ſubſtances that may be united with the ore of Zinc, or with the Zinc itſelf, not having the ſame volatility, cannot be reduced to vapours. If you are appriſed that the Calamine, or other ore of Zinc uſed on this occaſion, is contaminated with a mixture of any other metallic matter, you muſt mingle luting earth with the charcoal-duſt and the matter containing the Zinc; make it into ſtiff paſte with water; of this make a bed at the bottom of your crucible, and ram it hard down; lay the Copper plates thereon, cover them with charcoal-duſt, and then proceed as before. By this means when the Copper melts it cannot fall to the bottom of the crucible, nor mix with the ore; but is borne up by the mixture, and cannot combine with any thing but the Zinc, that riſes in vapours, and, paſſing through the lute, fixes in the Copper.

Lapis Calaminaris, or other ore of Zinc, may alſo be purified before it be uſed for making Braſs; eſpecially if adulterated with Lead ore, which is often the caſe. For this purpoſe the ore muſt be roaſted in a fire ſtrong enough to give a ſmall degree of fuſion to the leaden matter; which will thereby be reduced into larger, heavier, and tougher maſſes. The moſt ſubtile particles are diſſipated in the torrefaction, together with ſome of the Calamine. The Calamine, on the contrary, is by roaſting made more tender, lighter, and much more friable. When it is in this condition, put it into a waſhing tray or van; dip the tray in a veſſel full of water, and bruiſe the matter it contains. The water will carry off the lighteſt powder, which is the Calamine, and leave nothing at the bottom of the tray but the heavieſt ſubſtance; that is the leaden matter, which is to be rejected as uſeleſs. The powder of the Calamine will ſettle at the bottom of the veſſel, where, after pouring off the water, it may be found, and uſed as above directed.

In this operation the charcoal-duſt ſerves to prevent both the Copper and the Zinc from being calcined: and for this reaſon, when you work on a great quantity of materials at once, it is not neceſſary to uſe ſo much charcoal-duſt, in proportion, as when you work but on a ſmall quantity; becauſe, the greater the maſs of metal, the leſs eaſily will it calcine.

Though the Copper melts in this operation, yet it is far from being neceſſary to apply ſuch a ſtrong fire as Copper uſually requires to melt it: for the acceſſion of the Zinc, on this occaſion, communicates to it a great deal of fuſibility. The increaſe of its weight is alſo owing to the quantity of Zinc combined with it. Copper acquires ſtill another advantage by its aſſociation with this ſemi-metal; for it remains longer in the fire without calcining.

Braſs well prepared ought to be malleable when cold. But in whatever manner it be made, and whatever proportion of Zinc there be in it, it is conſtantly found quite unmalleable when red-hot.

Braſs melted in a crucible, with a fierce heat, takes fire almoſt like Zinc, and from its ſurface many white flowers aſcend, dancing about in flakes like the flowers of Zinc. They are indeed the flowers of Zinc, and the flame of Braſs urged by a ſtrong fire is no other than the flame of the Zinc that is united with the Copper, and at that time burns. If Braſs be thus kept long in fuſion it will loſe almoſt all the Zinc it contains. It will alſo loſe much of its weight, and its colour will be nearly that of Copper. It is therefore neceſſary, towards performing this operation aright, to ſeize the moment when the Copper is ſufficiently impregnated with Zinc, when it hath acquired the moſt weight and the fineſt colour, with the leaſt detriment to its ductility, that is poſſible, and that inſtant to put out the fire; becauſe, if the Copper be left longer in fuſion, it will only loſe the Zinc already united with it. Skill acquired by much practice, and an acquaintance with the particular Calamine employed, are neceſſary to guide the artiſt ſurely through this operation; for there are very conſiderable differences between the ſundry ores of Zinc. Some of them contain Lead, as was ſaid above, and in others there is Iron. When theſe heterogeneous metals come to be mixed with the Copper, they do indeed augment its weight, but they render it at the ſame

time

time pale, and make it very harſh. Some Calamines require to be roaſted before they can be uſed for this purpoſe, and in the torrefaction emit vapours of a Volatile Alkali, ſucceeded by vapours of a Sulphureous Spirit: others exhale no vapours while roaſting, and may be employed without any antecedent preparation. Theſe different qualities muſt evidently produce great differences in the operation.

Braſs may alſo be made as Prince's metal and other imitations of Gold are actually made, by uſing Zinc in ſubſtance, inſtead of the ores that contain it. But theſe compoſitions have not, when cold, the ductility of Braſs prepared with *Lapis Calaminaris*, becauſe Zinc is ſeldom pure, or free from a mixture of Lead. Perhaps alſo the different manner in which the Zinc unites with the Copper may contribute to this variation.

To obviate this inconvenience, the Zinc muſt be refined from all alloy of Lead The property of being indiſſoluble by Sulphur, which this ſemi-metal poſſeſſes, points out a very practicable method of doing it. The Zinc muſt be melted in a crucible, and ſtirred briſkly with a ſtrong iron wire, while tallow and mineral Sulphur are alternately projected upon it; but ſo that the quantity of Sulphur may greatly exceed that of the tallow. If the Sulphur do not burn entirely away, but form a kind of ſcoria on the ſurface of the Zinc, it is a ſign that your ſemi-metal contains Lead. In this caſe you muſt continue throwing in more Sulphur, and keep ſtirring the Zinc inceſſantly, till you perceive that the Sulphur ceaſes to unite any more with a metallic ſubſtance, but burns freely on the ſurface of the Zinc. The ſemi-metal is then refined; becauſe the Sulphur, which cannot diſſolve it, unites very readily with the Lead, or other metallic ſubſtance, contained in it.

If Zinc thus refined be mixed with pure Copper, in the proportion of a fourth or a third part, and the mixture be kept in fuſion and conſtantly ſtirring for ſome time, the Braſs produced will be as ductile, when cold, as that made by cementation with the *Lapis Calaminaris*.

With regard to Prince's metal, and other imitations of Gold, they are made either with Copper or Braſs re-combined with more Zinc. As it is neceſſary, for giving them a fine golden colour, to mix with them other proportions of Zinc than that acquired to make Braſs only, they are generally much leſs ductile. In 1725, M. Geoffroy gave a Memoir on this ſubject, in which he examined the effects of incorporating both Copper and Braſs with Zinc, from a ſmall to a very large quantity.

PROCESS IV.

Zinc diſſolved in the Mineral Acids.

WEAKEN concentrated Oil of Vitriol by mixing with it an equal quantity of water. Into a matraſs put the Zinc you intend to diſſolve, firſt broken to ſmall pieces. Pour on it ſix times its weight of the Vitriolic Acid, lowered as above directed, and ſet the matraſs in a ſand-bath gently heated. The Zinc will diſſolve entirely, without any ſediment. The Neutral Metallic Salt reſulting from this diſſolution ſhoots into cryſtals, which go by the name of *White Vitriol*, or *Vitriol of Zinc*.

OBSERVATIONS.

THOUGH Zinc be ſoluble in all the Acids, and when combined with thoſe Acids exhibits ſome uncommon phenomena, yet M. Hellot is the firſt that ever gave a particular account of what happens in thoſe diſſolutions: ſo that all we have to ſay on this head is extracted from that Gentleman's Memoirs. If a ſolution of Zinc in the Vitriolic Acid, prepared according to the directions in the proceſs, be diſtilled from a retort placed in a ſand-bath with a graduated heat, almoſt half the liquor preſently comes over in pure phlegm. A ſmall quantity of a Sulphureous Acid Spirit riſes next. A greater force of fire is now requiſite: the retort muſt therefore be removed into a reverberatory, and the diſtillation continued with a naked fire. On the firſt impreſſion of this heat an odour of Liver of Sulphur diſcovers itſelf, which becomes ſharp and ſuffocating towards the end of the diſtillation. In two hours time white vapours begin to appear, as in the rectification of common Oil of Vitriol. If the receiver be then ſhifted, you will obtain an Oil of Vitriol, in quantity about the eighteenth part of the whole uſed in the diſtillation, which, though ſulphureous, is yet ſo concentrated, that, if a few drops thereof be poured into a weak Oil of Vitriol, they fall to the bottom with as much noiſe as if they were ſo many bits of red-hot iron, and heat this Oil of Vitriol as much as common Oil of Vitriol heats water.

At the bottom of the retort there remains a dry, white, cryſtalline, ſaline maſs, exceeding in weight the Zinc that was diſſolved, about a twelfth part of the whole weight of the liquor. The increaſe of its weight is owing to a portion of the Vitriolic Acid that remains concentrated in the Zinc, and could not be expelled by the fire. This portion of Acid adheres to it moſt tenaciouſly: for, though M. Hellot kept the retort containing it during two whole hours in ſo violent a fire that the veſſel began to melt, the ſmalleſt vapour did not riſe from it.

This ſaline *caput mortuum* is in the form of needles, much like the Sedative Salt. It is cauſtic, grows conſiderably hot when water is poured on it, and gives in the air, but ſlowly. Spirit of wine, digeſted with this Salt for eight or ten days, acquires the ſame ſmell as that which is mixed with concentrated Oil of Vitriol in preparing Æther.

Zinc is diſſolved by the Nitrous and Marine Acids, much in the ſame manner as by the Vitriolic; except that the Marine Acid does not touch a black, ſpungy, rarefied matter, which it ſeparates from the Zinc. M. Hellot found upon trial that this matter is not Mercury, and that it cannot be reduced to a metallic ſubſtance.

That ingenious Chymiſt diſtilled likewiſe Solutions of Zinc in the Nitrous and Marine Acids. There came over at firſt, as there did from the ſolution made by the Vitriolic Acid, an aqueous, and then an acidulated liquor. At laſt, by exciting the fire with great violence, towards the end of the diſtillation, he obtained a ſmall quantity of the Acid that hath been employed in the diſſolution: but the ſmall portion of Acid thus obtained was exceeding ſtrong; and the quantity of the Nitrous much more conſiderable than that of the Marine Acid.

A ſolution of Zinc in the Marine Acid, being diſtilled to dryneſs, yields a Sublimate on applying a violent heat to it.

All the Acids diſſolve with eaſe, not only Zinc, but its Flowers alſo; and that nearly in the ſame quantity, and with almoſt all the ſame phenomena. M. Hellot, obſerving that the reſidues of moſt of the ſolutions of Zinc have a great reſemblance with its flowers, is of opinion that this ſemi-metal may be reduced, by the means of ſolvents, to the ſame ſtate into which it is brought by the fire when ſublimed in Flowers.

CHAP. IV.

Of ARSENIC.

PROCESS I.

To extract Arſenic from its Matrices. Zaffre or Smalt.

POWDER ſome Cobalt, white Pyrites, or other Arſenical matters. Put this powder into a retort with a ſhort wide neck, leaving a full third thereof empty. Set your retort in a reverberating furnace; lute on a receiver; heat your veſſel by degrees, and increaſe the fire till you ſee a powder ſublime into the neck of the retort. Keep up the fire in this degree as long as the ſublimation continues: when this begins to ſlacken, raiſe your fire, and make it as ſtrong as the veſſels will bear. When nothing more aſcends, let it go out. On unluting the veſſels, you will find in the receiver a little Arſenic in the form of a fine light *farina*. The neck of the retort will be full of white flowers, not quite ſo fine, ſome of which will appear like little cryſtals; and if a good deal of Arſenic be ſublimed, a ponderous matter, like a white, ſemi-tranſparent glaſs, will be found adhering to that part of the neck of the retort which is next its body.

OBSERVATIONS.

ARSENIC is a metallic ſubſtance ſtill more volatile than Zinc; ſo that it cannot be ſeparated from the matters with which it is mixed otherwiſe than by ſublimation. It is proper, however, to take notice, that it is not naturally in a metallic form, and that, properly ſpeaking, the whole Sublimate obtained from Cobalt, as above directed, is nothing but a metallic calx, that cannot be brought to the form and gloſs of a metal, till it be worked up with fatty matters, as we ſhall ſhew in its place.

This calx is of a very ſingular nature, and differs from every other metallic calx, in that this is volatile, and all the reſt extremely fixed; even thoſe procured from the ſemi-metals: for the Flowers of Zinc, which are juſtly conſidered as a calcined Zinc, though obtained by a ſort of ſublimation, are not for all that of a volatile nature, but rather exceedingly fixed; ſeeing they are capable of ſuſtaining the moſt violent fire, and melt inſtead of ſubliming. Arſenic, on the contrary, is not only extracted from its ore by ſublimation, but when once ſublimed continues to be volatile, and flies off in vapours as ſoon as it is expoſed even to a moderate degree of heat.

This metallic matter, before it is combined with the phlogiſton, is called *White Arſenic*, or plain *Arſenic:* it acquires the title of *Regulus of Arſenic* when it is united with the phlogiſton, and glitters like a metal.

Though Arſenic be volatile, yet it requires a pretty ſtrong fire to ſeparate it from the minerals containing it, eſpecially in cloſe veſſels; becauſe it adheres very cloſe to earthy and vitrifiable matters. This adheſion is ſo firm, that, when thus combined, it is capable of bearing a melting heat, and vitrifies with metallic calces, and other fuſible matters. On this account it is impoſſible to extract from Cobalt, or other Arſenical matters, all the Arſenic they contain by working them only in cloſe veſſels. If ſuch matters are to be freed from all their Arſenic, you muſt, after you have extracted all they will yield by diſtillation, put them into a crucible, and ſet it uncovered in the midſt of a ſtrong fire. Many Arſenical vapours will ſtill riſe; and care muſt be taken to ſtir the contents of the crucible frequently with an iron rod, to facilitate the diſcharge of the remaining Arſenic.

It often happens that the Arſenic, obtained from minerals by ſublimation, is not very white, but of a lighter or darker grey colour. This is owing to ſome particles of inflammable matter, from which Arſenical minerals are ſeldom quite free. A very ſmall quantity of phlogiſton is ſufficient to deprive much Arſenic of its whiteneſs, and to give it a grey colour. But when fouled in this manner, it may eaſily be brought to its due degree of whiteneſs: it need only be ſublimed once more, after mixing it with ſome ſubſtance on which it doth not act; Sea-ſalt, for inſtance. If the matters from which Arſenic is extracted contain Sulphur alſo, as ſome pyrites do, the Arſenic ſublimes with much leſs heat, than when it is united with earthy matters only; becauſe it combines with the Sulphur, wherewith it hath a great affinity, and the Sulphur ſerves to ſeparate the Arſenic, by this interpoſition, from the earth. In conſequence hereof, Sulphur may be employed to extract Arſenic out of the earths in which it is fixed. In this caſe, the Sulphur changes the colour of the Arſenic, which it makes of a lighter or deeper yellow, or even red, in proportion to the quantity there is of it, and to the degree of fire that hath acted on both together.

The conſiſtence of Arſenic is different, according to the degree of heat applied in ſubliming it. If the Arſenical vapour meet with a cold place, it gathers there in the form of a powder, as the Flowers of Sulphur do: this is the caſe with that which falls into the receiver in diſtilling it. But if it be ſtopped in a hot place, and cannot eſcape from that heat, it condenſes into a heavy, compact, ſemi-tranſparent body, having undergone the firſt degree of fuſion.

Yet it cannot be perfectly melted, ſo as to flow like other fuſed matters: not that it is refractory; for, on the contrary, the degree of heat in which it begins to melt is very moderate, and it is in its own nature very fit to promote the fuſion of refractory matters: but the reaſon is this; it is neceſſarily converted into vapours by the degree of heat neceſſary to fuſe it, and theſe vapours burſt the veſſels, if they find no vent.

Arſenic made yellow by a mixture of Sulphur, which is alſo called *Orpiment*, is reducible to the form of a ſolid Sublimate with more eaſe; becauſe it is alloyed with a twentieth, or perhaps a tenth part, of its weight of Sulphur, which renders it more fuſible.

Red Arſenic, which contains ſtill more Sulphur, melts alſo more eaſily. It then becomes of a tranſparent red, like a ruby: and hence, when it is in this form, it is called *Ruby of Arſenic.*

When a combination of Sulphur and Arſenic is wanted, it is better to mingle and diſtil together ſuch minerals as contain Sulphur and Arſenic, the white and the yellow pyrites, for inſtance, than to mingle pure Arſenic with pure Sulphur: for the great volatility of theſe two ſubſtances is a hinderance to their uniting; whereas, when combined with other matters, they are capable of ſuſtaining a much greater degree of heat, which favours and promotes their union.

Thoſe who work by the great do not extract Arſenic out of Cobalt by diſtillation: they throw the ore mixed promiſcuouſly with wood and charcoal into a great furnace, from whence a flue carries the vapours into a long winding paſſage, acroſs which beams of wood are fixed at proper diſtances from each other. The Arſenical vapours being conducted into this paſſage, adhere both to the ſides thereof and to the joiſts that lye acroſs it. The fuliginous parts of the combuſtible matters being lighter aſcend higher, and go out through a chimney at the farther end of this paſſage.

The Arſenic ſublimed by this method is not white, but of a grey colour; owing to the inflammable matter of the wood and charcoal with which the ore is torrefied.

When all the Arſenic the Cobalt will yield is thus ſeparated, the earthy fixed matter left behind is mixed with divers fuſible matters and vitrified, and produces a glaſs of a beautiful blue colour. It is called *Smalt*. This glaſs is to be prepared in the following manner.

Take four parts of fine fuſible ſand, an equal quantity of any Fixed Alkali perfectly depurated, and one part of Cobalt from which the Arſenic hath been ſublimed by torrefaction. Pulverize theſe different ſubſtances very finely, and mix them thoroughly together; put the mixture into a good crucible, cover it, and ſet it in a melting furnace. Make a ſtrong fire, and keep it up conſtantly in the ſame degree for ſome hours. Then dip an iron wire into the crucible; to the end of which a glaſſy matter will ſtick, in the form of threads, if the fuſion and vitrification be perfect. In this caſe take the crucible out of the fire; cool it by throwing water on it, and then break it. You will find in it a glaſs, which will be of an exceeding deep blue, and almoſt black, if the operation hath ſucceeded. This glaſs, when reduced to a fine powder, acquires a much brighter and more lively blue colour.

If you find after the operation that the glaſs hath too little colour, the fuſion muſt be repeated a ſecond time, with twice or thrice the quantity of Cobalt. If, on the contrary, the glaſs be too dark, leſs Cobalt muſt be uſed.

Inſtead of the mixture here preſcribed you may employ a ready-made glaſs, providing it be white and fuſible. But as glaſs is always hard to melt, and as the mixing Cobalt with it renders it ſtill more refractory, therefore though an Alkaline Salt be one of the ingredients in its compoſition, it is proper to promote the fuſion, by mixing therewith calcined wine-lees, in the quantity of one third part of the weight of the Cobalt.

In order to make the aſſay of a particular Cobalt, with a view to know what quantity of blue glaſs it will yield, it is neceſſary to perform the operation in the manner here ſet down; a great deal of time and trouble may be ſaved by melting one part of Cobalt with two or three parts of Borax. This Salt is very fuſible, and turns, when melted, into a ſubſtance which, for a time, poſſeſſes all the properties of glaſs. In this trial the glaſs of Borax will be nearly of the ſame colour as the true glaſs, or Smalt, made with the ſame Cobalt.

The ores of Biſmuth, as well as Cobalt, yield a matter that colours glaſs blue; nay, the Smalt made with theſe ores is more beautiful than that procured from the ore of pure Arſenic. Some Cobalts yield both Arſenic and Biſmuth. When ſuch Cobalts are uſed, it is common to find at the bottom of the crucible a little button of metallic matter, which is called *Regulus of Cobalt*. This Regulus is a ſort of Biſmuth, generally adulterated with a mixture of ferruginous and arſenical parts.

The heavieſt and moſt fixed Flowers of Arſenic, procured from Cobalt, have likewiſe the property of giving a blue colour to glaſs. But this colour is faint: it is owing to a portion of the colouring matter carried up along with the Arſenic. Theſe Flowers may be made an ingredient in the compoſition of blue glaſs, not only becauſe of the colouring principle they contain, but alſo becauſe they greatly promote fuſion; Arſenic being one of the moſt efficacious fluxes known.

In ſhort, all thoſe blue glaſſes, or Smalts, contain a certain quantity of Arſenic; for a portion of this ſemi-metal always remains united with the fixed matter of the Cobalt, though roaſted for a long time, and in a very hot fire. The portion of Arſenic that is thus fixed vitrifies with the colouring matter, and enters into the compoſition of the Smalt.

The blue glaſs made with the fixed part of Cobalt hath ſeveral names, according to the condition in which it is. When it hath undergone the firſt imperfect degree of fuſion only it is called *Zaffre*. It takes the name of *Smalt* when perfectly vitrified: and this again being pulverized is called *Powder-blue*, or, if finely levigated, *Blue Enamel;* becauſe it is uſed in enamelling, as well as in painting earthen ware and porcelain.

PROCESS II.

To ſeparate Arſenic from Sulphur.

POWDER the yellow or red Arſenic which you intend to ſeparate from its Sulphur. Moiſten this powder with a Fixed Alkali reſolved into a liquor. Dry the mixture gently; put it into a very tall glaſs cucurbit, and fit on a blind-head. Set this cucurbit in a ſand-bath; warm the veſſels gently, and increaſe the fire by degrees, till you perceive that no more Arſenic ſublimes. The Arſenic, which before was yellow or red, riſes into the head partly in white flowers, and partly in a compact, white, ſemi-tranſparent matter, which looks as if it were vitrified. The Sulphur combined with the Fixed Alkali remains at the bottom of the cucurbit.

OBSERVATIONS.

A Fixed Alkali hath more affinity than any metallic ſubſtance with Sulphur: ſo that it is not ſurpriſing Sulphur ſhould be ſeparated from Arſenic by its interpoſition. Yet there is an inconvenience attends the uſe of it: for it hath a great affinity with the Arſenic alſo, and ſo always retains ſome part thereof, which continues fixed with it. For this reaſon care ſhould be taken not to mix, with ſulphurated Arſenic, a greater quantity of Alkali than is neceſſary to abſorb the Sulphur it contains. Nothing, however, but experience and repeated trials can teach us the exact quantity of Alkali that ought to be employed; becauſe the quantity of Sulphur that may be contained in yellow or red Arſenic is indefinite.

The veſſel ought to be tall, that the upper part of the head, where the Arſenical particles condenſe, may be the leſs expoſed to heat. Towards the end of the operation the fire muſt be ſtrongly excited, ſo as to make the ſand red-hot; becauſe the laſt portions of Arſenic that riſe are ſtrongly retained by the Fixed Alkali.

Arſenic that is grey or blackiſh may be depurated and whitened by the ſame means; becauſe a Fixed Alkali abſorbs the phlogiſton likewiſe with great avidity. Mercury, as well as a Fixed Alkali, is an excellent additament for ſeparating Arſenic from Sulphur. If you will uſe it for that purpoſe, reduce the ſulphurated Arſenic to a very fine powder, by rubbing it a long time in a glaſs mortar; when it is well pulverized, let a few drops of Mercury fall upon it, by ſqueezing it through chamoy, and continue the trituration. The yellow or red colour of the Arſenic will inſenſibly change, and gradually grow darker as the Mercury incorporates with it. When the Mercury is perfectly killed, add a little more of it than you did the firſt time, and in the ſame manner: continue to triturate till it diſappear; and thus go on adding more and more till the Mercury you add remain quick, and you can kill no more of it. Neither the red nor the yellow colour will then appear in the mixture; which will be grey, if it contain but a little Sulphur, and black, if a great deal.

Put this mixture into a very tall glaſs cucurbit; fit on a blind-head; ſet it in a ſand-bath, and bury it in the ſand as far as the contained mixture reaches. Heat the veſſels, and, during the whole operation, keep up a degree of fire a little weaker than that required for ſubliming Cinabar. White Arſenical Flowers will adhere to the upper part of the head, amongſt which will be ſome beautiful cryſtals of Arſenic; and underneath them you will find ſome Cinabar ſublimed, but not entirely free from Arſenic. If you deſire to have your Cinabar and your Arſenic purer, and more unmixed with each other, ſeparate the upper ſublimate, which is Arſenical, from the lower, which conſiſts chiefly of Cinabar. Powder each of them coarſely, and ſublime them ſeparately each in a different cucurbit.

On this occaſion the Mercury ſeparates the Sulphur from the Arſenic, becauſe it hath a greater affinity than Arſenic with that mineral. It is not the only metallic ſubſtance of this character: for, as hath been ſhewn, there are ſeveral others that have a greater affinity than Mercury with Sulphur, being able to decompoſe Cinabar by their interpoſition. Yet thoſe metallic ſubſtances muſt not be ſubſtituted for Mercury in the preſent operation: becauſe there is none of them but hath at the ſame time a very great affinity with Arſenic, or even as ſtrong an one as they have with Sulphur; whereas Mercury will by no means unite with Arſenic.

This method of ſeparating Arſenic from Sulphur hath two advantages over that in which a Fixed Alkali is the medium. The firſt is, that by this means all the Arſenic contained in the mixture is extracted out of it; and the ſecond, that, as Mercury doth not abſorb Arſenic, we are not put to the trouble of groping out, as it were, by trials the quantity neceſſary to be added; and that, though more be added than is neceſſary to abſorb all the Sulphur, it will be of no prejudice to the operation. But then it is attended with the inconvenience of being much more tedious and more laborious than the other. For, in the firſt place, it requires previouſly a very tireſome trituration, in order to procure an union between the Sulphur and the Mercury, and ſo to form an Æthiops; without which the Mercury and the ſulphurated Arſenic will ſublime ſeparately, ſo that no decompoſition will be effected. Secondly, though the Mercury be ſufficiently united with the Sulphur of the Arſenic by the long trituration that precedes the ſublimation, this doth not prevent, as we took notice above, the ſublimed Arſenic and

Cinabar from being in ſome meaſure blended together; ſo that each requires a ſecond ſeparate ſublimation to render it very pure.

Theſe inconveniencies cauſe a Fixed Alkali to be uſed preferably to Mercury; the loſs of a ſmall quantity of the Arſenic, which remains united with the Alkali, being little regarded; as that metallic ſubſtance is neither ſcarce nor precious.

When Arſenic is united with a great quantity of Sulphur, it may be freed from a part thereof without the intervention of any third body: it is ſufficient for the purpoſe to ſublime it with a very gentle fire, increaſed by inſenſible degrees. The moſt ſulphureous part aſcends firſt; what riſes afterwards is more Arſenical, and leſs ſulphureous; and the laſt flowers of all are pure Arſenic, or at leaſt nearly ſo.

PROCESS III.

To give Arſenic the Metalline Form. Regulus of Arſenic.

TAKE two parts of white Arſenic in fine powder, one part of the black flux, half a part of Borax, and as much clean iron filings. Rub the whole together, in order to mix them thoroughly. Put this mixture into a good crucible, and over it put Sea-ſalt three fingers thick. Cover the crucible; ſet it in a melting furnace; and begin with a gentle fire to heat the crucible equally.

When arſenical vapours begin to aſcend from the crucible, raiſe the fire immediately ſo as to melt the mixture. Examine whether or no the matter be thoroughly melted, by introducing an iron wire into the crucible; and if the fuſion be perfect, take the crucible out of the furnace. Let it cool; break it; and you will find in it a Regulus of a white and livid metallic colour, very brittle, ſcarcely hard, but rather friable.

OBSERVATIONS.

WHITE Arſenic is, as hath been ſaid, a metallic calx; and conſequently wants no more, in order to its acquiring the metalline properties, than to be combined with the phlogiſton: this is effected by the operation before us.

The Iron added doth not ſerve here, as in making the Regulus of Antimony, to precipitate the Regulus of Arſenic, by ſeparating it from ſome other ſubſtance with which it was united: on this occaſion it does nothing but join the Regulus of Arſenic, to which it gives ſolidity and conſiſtence. This is the only reaſon of its being made an ingredient in the mixture; as the Regulus of Arſenic, without it, would have ſuch a tender conſiſtence, that it could ſcarce be handled without falling aſunder into little bits. The Iron procures a further advantage in this proceſs; which is, that it prevents a great quantity of Arſenic from being loſt in vapours: for the Arſenic, with which it combines, is reſtrained, and, in ſome meaſure, fixed by it.

Copper may be ſubſtituted for Iron, and procures the ſame advantages.

It is very neceſſary to remove the crucible from the fire as ſoon as the matter is melted, and indeed to cool it as expeditiouſly as poſſible, to prevent the Arſenic from flying off in vapours: for, when once the Regulus is formed, the proportion of Arſenic, with reſpect to that of the metal mixed with it, is continually leſſening while it ſtays in the fire; ſo that, after ſome time, there will be left in the crucible, not a Regulus of Arſenic, but only Iron or Copper, alloyed with a little Arſenic. On this occaſion the Copper turns white, and aſſumes the colour of Silver; but it ſoon tarniſhes in the air.

It is eaſy to perceive, by what hath been ſaid, that the Regulus of Arſenic made according to this proceſs is never pure, but contains always a conſiderable quantity of Iron or Copper, whatever precautions be uſed: but it is difficult to avoid this inconvenience, for the reaſons above aſſigned; and if we attempt to fuſe Arſenic alone, with reducing fluxes, the greateſt part thereof is diſſipated in vapours, long before the very flux begins to melt: and that part of it, which is found metallized, is not collected in one maſs at the bottom of the crucible, as in other metallic reductions; but in ſmall particles, diſperſed and mixed among the ſcoriæ. There are nevertheleſs ſeveral expedients for obtaining a Regulus of Arſenic abſolutely pure, and unalloyed with any metallic ſubſtance.

Firſt: into a little low cucurbit, covered with a blindhead, put Regulus of Arſenic made with Iron or Copper; ſet this cucurbit in a ſand-bath; heat it till the ſand begins to grow red, and you will ſee part of the Regulus ſublime into the head, ſtill retaining its metalline ſplendour. The portion of Regulus thus ſublimed is pure Arſenic, or at leaſt contains but a very ſmall portion of the adventitious metal, which may have been carried up with it. What is left in the bottom of the cucurbit is the metal that was added, ſtill containing a little Arſenic, which continues obſtinately fixed with it, and which the violence of fire is unable to force away from it in cloſe veſſels.

Secondly: mix your Arſenic in equal parts with the black flux; put the mixture into ſuch a cucurbit as that laſt mentioned; and apply to it the ſtrongeſt degree of heat that can be procured by a ſand-bath; arſenical flowers, of a blackiſh grey colour, will firſt ſublime into the head, and after them a Regulus of Arſenic of a white metalline colour, which is pretty gloſſy, but tarniſhes very ſoon in the air. This Regulus hath no ſolidity: it is exceedingly friable; but it is pure.

Thirdly: I have alſo made a Regulus of pure Arſenic by another method, which produces a much greater quantity thereof, with a much ſmaller degree of heat. For this purpoſe I powder the Arſenic, and mix with it any Fat Oil; ſo that the mixture may be like a liquid paſte: this paſte I put into a little phial of thin glaſs, like one of thoſe uſed by apothecaries; I ſet this phial in a ſand-bath, and gradually heat it, till the bottom of the pot containing the ſand begin to be red. Part of the Oil firſt riſes out of the phial in vapours, which muſt be ſuffered to paſs off. After this the upper part of the phial is gradually lined, on the inſide, with a glittering metallic cruſt, which makes it look like a quick-ſilvered glaſs. This cruſt is the Regulus of Arſenic. When it begins to ſublime, the mouth of the phial muſt be ſlightly ſtopped with a bit of paper, and the heat increaſed a little, till you ſee that nothing more riſes.

If you break the bottle after the operation, you will find its upper part cruſted over with a coat of Regulus, thicker or thinner in proportion to the quantity of Arſenic employed. The Regulus is in a maſs, of a beautiful brilliant colour, which to me ſeems to ſtand the air better than that of any Regulus made by other methods; probably becauſe of the great quantity of fat matter with which it is united, and by which it is defended.

This Regulus of Arſenic is abſolutely pure, and a much greater quantity thereof is obtained, by this method, than by treating it with the black flux; becauſe the Arſenic is much ſooner and more eaſily combined with the inflammable matter: and hence it comes to paſs that part of the Arſenic doth not riſe at firſt in grey flowers, as in operating with the black flux. Moreover, by our proceſs, all the Arſenic is ſublimed in Regulus: whereas, when the black flux is employed, a pretty conſiderable part of the Arſenic unites with the alkaline part of the flux, and remains fixed therewith. In our operation there is nothing left at the bottom of the phial, except an oily, light, but very fixed coal.

Regulus of Arſenic, in whatever manner made, may be eaſily reduced into white, cryſtalline Arſenic, by the means of a Fixed Alkali, or of Mercury, applied in the ſame manner as for ſeparating Arſenic from Sulphur.

PROCESS IV.

To diſtil the Nitrous Acid by the interpoſition of Arſenic. Blue Aqua Fortis. *A new Neutral Salt of Arſenic.*

PULVERIZE finely any quantity you pleaſe of refined Salt-petre. Mix it accurately with an equal weight of white cryſtalline Arſenic, well pulverized, or elſe with very white and very fine flowers of Arſenic. Put this mixture into a glaſs retort, leaving one half of it empty. Set your retort in a reverberating furnace; apply a receiver having a ſmall hole drilled in it, and containing a little filtered rain-water; lute the receiver to the retort with ſtiff lute. Begin with putting two or three ſmall live coals in the aſh-hole of the furnace, and replace them with others when they are ready to go out. Go on thus warming your veſſels by inſenſible degrees, and put no coals in the fire-place, till the retort begin to be very warm. You will ſoon ſee the receiver filled with vapours of a dark-red, inclining to a ruſſet colour. With a bit of lute ſtop the little hole of the receiver. The vapours will be condenſed in the water of this veſſel, and give it a very fine blue colour, that will grow deeper and deeper as the diſtillation advances. If your Salt-petre was not very dry, ſome drops of Acid will alſo come over, and falling from the noſe of the retort mix with the water in the receiver. Continue your diſtillation, increaſing the fire little by little as it advances, but exceeding ſlowly, till you ſee that when the retort is red-hot nothing more comes off; and then let your veſſels cool.

When the veſſels are cold, unlute the receiver, and, as expeditiouſly as you can, pour the blue *aqua fortis* it contains into a cryſtal bottle; which you muſt ſeal hermetically, becauſe this colour diſappears in a ſhort time when the liquor takes air. You will find in the retort a white ſaline maſs

moulded

moulded in its bottom, and ſome flowers of Arſenic ſublimed to its upper cavity, and into its neck.

Pulverize the ſaline maſs, and diſſolve it in warm water. Filter the ſolution, in order to ſeparate ſome arſenical parts that will be left on the filter. Let the filtered liquor evaporate of itſelf in the open air; when it is ſufficiently evaporated, cryſtals will ſhoot in it repreſenting quadrangular priſms, terminated at each extremity by pyramids, that are alſo quadrangular. Theſe cryſtals will be in confuſed heaps at the bottom of the veſſel: over them will be other cryſtals in the form of needles; a ſaline vegetation creeping along the ſides of the veſſel; and the ſurface of the liquor will be obſcured by a thin duſty pellicle.

OBSERVATIONS.

ARSENIC, as we took notice in our Elements of the Theory, beſides the properties it hath in common with metallic ſubſtances, poſſeſſes others alſo in common with ſaline ſubſtances. One of the moſt remarkable among the latter is that of decompoſing Nitre; of expelling the Acid of that Salt from its Alkaline baſis, aſſuming its place, and forming with that Alkali a Neutral Salt, which is very ſoluble in water, and ſhoots into regular cryſtals.

To inquire into what paſſes in the decompoſition of Nitre by Arſenic, and into the new Salt reſulting from thence, was the deſign of the firſt Memoir given in by me to the Academy of Sciences on this ſubject, and from that the preſent proceſs is copied. Though the whole quantity of Arſenic preſcribed in the proceſs doth not enter into the compoſition of the new Neutral Salt, ſeeing ſome of it ſublimes in flowers, that quantity muſt not therefore be thought too great: for we ſee, on the other hand, that part of the Nitre is not decompoſed. The needle-like Salt is no other than Nitre that hath not ſuffered any decompoſition, and actually deflagrates on live coals like common Nitre.

The precaution of putting ſome water in the receiver is abſolutely neceſſary, to condenſe the nitrous vapours that riſe in the diſtillation: for they are ſo elaſtic, ſo volatile, ſo dephlegmated, that a very ſmall part of them will otherwiſe be condenſed into a liquor, while the reſt will remain in the form of vapours, to which vent muſt be given through the ſmall hole in the receiver, as without that they will burſt the veſſels with impetuoſity: and conſequently ſcarce any

Acid will be obtained; eſpecially if the Nitre employed be very dry, as it muſt be to be reducible into a fine powder.

The blue colour communicated by the Nitrous Acid to the water is very remarkable. The cauſe that produces this colour is not yet known.

Though the Acid is, on this occaſion, mortified by a great quantity of water, yet, when it riſes out of the retort, it is ſo concentrated as to form, even with that water, if too much be not put in, a moſt active and even ſmoking *aqua fortis*.

It is neceſſary in this operation, and more ſo than in any other, to warm the veſſels gradually, and to proceed exceeding ſlowly; otherwiſe the artiſt runs the riſque of ſeeing his veſſels burſt to pieces with violence, and with great danger to his perſon: for Arſenic acts on Nitre with incredible vivacity; inſomuch that, if a mixture of Nitre and Arſenic be heated to a certain degree, the Nitre is decompoſed almoſt as rapidly, and with as great an exploſion, as when it is made to fulminate with an inflammable matter. In ſhort, the appearances are ſuch, that one would be almoſt induced to think the Nitre really takes fire on this occaſion: though it be only decompoſed juſt as it is by the Vitriolic Acid.

The ſolution of the *caput mortuum* of this diſtillation contains, at the ſame time, ſeveral ſorts of Salts: to wit, 1. the Neutral Salt of Arſenic, formed by the union of the Arſenic with the baſis of the Nitre; this ſhoots into the priſmatic cryſtals above-mentioned: 2. ſome Nitre that hath not been decompoſed; this forms the needles and part of the vegetations: 3. a ſmall portion of Arſenic, that is known to be ſoluble in water; this forms the thin dark pellicle that covers the ſurface of the liquor when it begins to evaporate.

For the properties of this new Neutral Salt of Arſenic you may conſult what we have ſaid thereupon in our Elements of the Theory, and in the Memoirs of the Academy of Sciences.

PROCESS V.

To alkalizate Nitre by Arſenic.

MELT in a crucible the Nitre you intend to alkalizate. When it is melted, and moderately red, project upon it two or three pinches of pulverized Arſenic. A conſiderable effervefcence and ebullition will immediately be produced in the crucible, attended with a noiſe like that which Nitre makes, when it detonates with an inflammable matter. At the ſame time a thick ſmoke will riſe, which at firſt will ſmell like garlic, the odour peculiar to Arſenic; it will alſo ſmell afterwards like Spirit of Nitre. When the effervefcence in the crucible is over, throw again upon the Nitre as much pulverized Arſenic as you did the firſt time; and all the ſame phenomena will be repeated. Continue thus throwing in Arſenic in ſmall parcels, till it produce no more effervefcence; taking care to ſtir the matter at every projection with an iron wire, the better to mix the whole together. Then increaſe your fire, and melt what remains. Keep it thus in fuſion for a quarter of an hour, and then take the crucible out of the fire. It will contain a Nitre alkalizated by Arſenic.

OBSERVATIONS.

THIS operation, as well as the preceding one, is a decompoſition of Nitre by Arſenic; yet the reſult is very different: for, inſtead of a Salt capable of cryſtallizing, and diſcovering no tokens either of Acid or Alkali, we obtain, on this occaſion, only a Salt that runs into a liquor by the moiſture of the air, doth not cryſtallize, and hath all the properties of an Alkali.

Theſe differences ariſe only from the different manner in which the decompoſition of the Nitre, and the union of the Arſenic with the baſis of that Salt, is brought about. When the Nitrous Acid is diſtilled by the interpoſition of Arſenic, with a view to obtain the Arſenical Salt, the operation muſt be performed in cloſe veſſels; no greater degree of heat muſt be applied to the mixture than is neceſſary for enabling the Arſenic to act; and that heat muſt be adminiſtered very ſlowly and by inſenſible degrees. But, when the buſineſs is to alkalizate Nitre by the means of Arſenic, the operation is performed in a crucible, in a naked fire, with a ſtrong degree of heat, and that ſuddenly applied. The violence of the heat, the ſuddenneſs with which it is applied, the vivacity wherewith the Arſenic unites with the baſis of the Nitre; and, ſtill more than all theſe, the free acceſs of the air, occaſion the greateſt part of the Arſenic, which at firſt combines with the baſis of the Nitre after having expelled its Acid, to be preſently carried off and diſſipated in vapours;

and conſequently the baſis of the Nitre, not being ſufficiently ſaturated, diſcovers its Alkaline properties.

I ſay, the concurrence of the air contributes, ſtill more than all the reſt, to ſeparate the Arſenic from the Alkaline baſis of the Nitre; experience having taught me that the Neutral Salt of Arſenic is not to be alkalizated by the moſt violent force of heat, as long as it continues in cloſe veſſels, and the external air hath no communication with it; but that ſome of the Arſenic contained in that Salt is diſſipated, by expoſing it to a ſtrong heat in open veſſels.

The tumult and effervefcence that ariſe, when Arſenic is projected on Nitre fuſed in a crucible, are ſo conſiderable, and ſo nearly reſemble the detonation of Nitre with an inflammable matter, that we ſhould be tempted to think, if we truſted appearances only, that Arſenic furniſhes a combuſtible matter, and that the Alkalization of the Nitre is effected, on this occaſion, in the ſame manner as when it is fixed by charcoal: but, by examining attentively what paſſes, we eaſily diſcover that there is no inflammation at all, and that the Nitre is alkalizated in the manner and by the means above pointed out.

The firſt vapours that riſe, when Arſenic is projected on Nitre, are purely arſenical; and, if any cold body be put in their way, they adhere to it in the form of flowers. Theſe vapours are actual particles of Arſenic, carried up by the heat before they could come to act on the Nitre; but they are ſoon after mixed with Nitrous vapours, conſiſting of the Acid of the Nitre, which the Arſenic expels from its baſis as faſt as it comes to act on that Salt.

The nearer you come to the end of the operation, the more does the matter in the crucible loſe of its fluidity, though an equal fire be conſtantly kept up in the furnace. At laſt it becomes quite like a paſte, and the fire muſt be made much ſtronger to put it again in fuſion. The reaſon of this is, that Nitre when alkalizated is much leſs fuſible than when it is not ſo. The caſe is the ſame when this Salt is alkalizated by deflagration.

Though the Nitre, when alkalizated, makes no more effervefcence with Arſenic, and though, when kept in fuſion, it emits no more arſenical vapours, it doth not thence follow that it is a pure Alkali, and that it contains no Arſenic: it ſtill contains a large quantity thereof, but ſo ſtrongly united that the force of fire is not able to ſeparate them; which hath led ſome authors to give this Salt the title of *Fixed Arſenic*.

The exiſtence of Arſenic in this ſaline compound is eaſily diſcovered, by fuſing it with metallic ſubſtances, on which it produces the ſame effects as Arſenic.

With ſolutions of metals in the Acids, it alſo preſents almoſt the ſame phenomena as the Neutral Salt of Arſenic. Particularly it precipitates Silver diſſolved by the Nitrous Acid in a red powder, as that Salt does; and the differences obſerved between the precipitations made by our new Neutral Salt of Arſenic, and thoſe made by Nitre alkalizated with Arſenic, can be attributed only to the alkaline quality of the latter. See the Memoirs of the Academy for 1746.

PART II.

OF VEGETABLES.

SECTION I.

Operations on unfermented Vegetables.

CHAP. I.

Of the SUBSTANCES *obtained from* VEGETABLES *by* EXPRESSION *only.*

PROCESS I.

To expreſs and depurate the Juice of a Plant, containing its Eſſential Salt. The Cryſtallization of that Salt.

BEFORE ſun-riſe gather a good quantity of the plant from which you deſign to expreſs the juice, in order to obtain its Salt. Waſh it well in running water, to clear it of earth, inſects, and other adventitious matters. Bruiſe it in a marble mortar; put it into a bag of new, ſtrong, thick linen cloth; tye the bag tight, and commit it to a preſs. By preſſing it ſtrongly you will ſqueeze out a great quantity of green, thick juice, which will have the ſame taſte as the plant. Dilute this juice with ſix times as much pure rain-water, and filter it repeatedly through a woollen bag, till it paſs clear and limpid. Evaporate the filtered juice with a gentle heat, till it be almoſt as thick as before it was mixed with water. Put this inſpiſſated juice into a jar, or other veſſel of earth or glaſs; on its ſurface pour olive oil to the depth of a line, and ſet it in a cellar. Seven or eight months after this, pour off gently the liquor contained in the veſſel, the inſide of which you will find covered with a cryſtallized Salt. Separate the cryſtals gently; waſh them quickly with a little fair cold water, and dry them: this is the Eſſential Salt of the plant.

OBSERVATIONS.

Every plant is not equally diſpoſed to yield its Eſſential Salt, by the method here propoſed. Succulent vegetables only, whoſe juices are aqueous and not too viſcous, are fit for this purpoſe. Such, for example, as ſorrel, brook-lime, ſuccory, fumitory, water-creſſes, plantain, &c. An Eſſential Salt cannot be procured from thoſe that yield thick, viſcid, mucilaginous juices, ſuch as the ſeeds of flea-wort; unleſs their juices be previouſly attenuated by fermentation, and that viſcoſity deſtroyed which obſtructs the Cryſtallization of this Salt.

Nor can the Eſſential Salt be obtained in any quantity from vegetable matters abounding in Oil. Moſt kernels and ſeeds are of this ſort: they all contain a great quantity of fat oil, which ſo entangles and clogs this Salt, that the particles thereof cannot ſhoot away from the tenacious juices into cryſtals.

The ſame is to be ſaid of dry aromatic plants; becauſe they contain much eſſential oil, or reſinous matters that produce the ſame effect. It is true the Eſſential Salt itſelf contains a certain portion of oil; for it is no other than the Acid of the plant incorporated and cryſtallized with part of its oil and of its earth: but then the oil muſt not be in too great a quantity: becauſe it ſheaths the Acid, renders it clammy, as it were, and hinders it from extricating itſelf, ſo as to be able to exert its qualities, and appear in the form of Salt.

The plants, from which you intend to extract this Salt, ſhould be gathered in the morning before ſun-riſe; becauſe they are then moſt ſucculent, not being yet dried up or withered by the heat of the ſun.

The juice of plants obtained by expreſſion is very thick; becauſe it contains many particles of the bruiſed plant, that are unavoidably ſqueezed out along with it. In order to clear it of theſe ſuperfluous parts, it is proper to filter it; but as that would be difficult, on account of the thickneſs of the juice, it muſt be thinned, by diluting it with a quantity of water, ſufficient to give it the requiſite degree of fluidity.

Inſtead of thus diluting the expreſſed juice, the plant may be ground with water, before it is put into the preſs: it will by this means furniſh a more fluid juice, that will eaſily paſs through the filter. This method may be employed with ſucceſs on dry plants, or ſuch as are not very ſucculent. For this operation rain-water is to be preferred to any other; becauſe it is the pureſt: for all waters that have run ſome time through the earth, or on its ſurface, are to be ſuſpected of containing ſome ſaline or ſelenetic matter, which would mix with and deprave the Eſſential Salt.

The juice of the plant, when diluted with the quantity of water ſufficient to facilitate its filtration, is too aqueous to let the Salt it contains unite into cryſtals: it muſt therefore be evaporated, till it hath recovered a ſomewhat thicker conſiſtence. The heat applied for that purpoſe muſt be gentle; leſt the acid and oily parts, that are to form the Salt, be ſpoiled or diſſipated, as they are not very fixed. In ſummer, the heat of the ſun is ſufficient to effect this evaporation: but if you make uſe of this method, the juice to be evaporated muſt be put into ſeveral broad flat pans; that, a larger ſurface being expoſed to the action of the air and ſun, the evaporation may be the ſooner completed: for if the juice ſhould continue too long in the degree of heat requiſite for its evaporation, it might begin to ferment; which would be very detrimental.

The oil poured on the liquor prevents its fermenting, putrefying, or growing mouldy, during the long ſpace of time required for the cryſtallization of the Eſſential Salt.

Theſe Salts are excellent medicines, being endued with the ſame virtues as the plants from which they were obtained.

They cannot be procured from plants by diſtillation, though they conſiſt in a great meaſure of volatile principles: nor are they obtainable by any other proceſs that requires much heat; becauſe they are eaſily decompoſed, and the fire changes their natures entirely. The oily Acids extracted from plants by diſtillation do not cryſtallize, and always have an empyreumatic acrimony, that makes them very different from the Eſſential Salts, which are very mild and ſaponaceous.

PROCESS II.

To draw the Oils out of Kernels, Seeds, and Fruits, by Expreſſion.

POUND in a marble mortar, or grind in a mill, the kernels, ſeeds, or fruits, out of which you intend to expreſs the Oil. If your matters be meagre, and grind to meal, ſuſpend that meal in the ſteam of boiling water, in order to moiſten it a little, and then dry it.

Tye up your matter thus prepared in a new, ſtrong, thick, canvaſs bag, and put it into a preſs, between two iron plates previouſly heated in boiling water: ſqueeze it ſtrongly, and you will ſee the Oil run in ſtreams into the receiving veſſel.

OBSERVATIONS.

THE Fat Oil of Plants is particularly found in kernels, ſeeds, and ſome fruits; ſome kernels contain ſuch a vaſt quantity thereof, that, on being very ſlightly bruiſed in a mortar, they diſcharge it in great abundance. Sweet and bitter Almonds, Walnuts, and Lint-ſeed, are all of this kind; and require no other management but to be pounded and preſſed, to make them yield a great deal of Oil. But there are others more meagre, that being ground produce an almoſt dry flower. In order to facilitate the expreſſion of the Oil out of ſuch, they muſt be expreſſed, when ground, to the ſteam of boiling water. For this purpoſe the meal may be put into a fine ſieve, and that ſuſpended over a pan half-full of water kept boiling on the fire. The aſcending vapours will moiſten the flower, render it more unctuous, and facilitate the expreſſion of the Oil.

It is proper to dry it a little before it be put into the preſs, that it may yield as little water as poſſible along with the Oil. Neverthelefs, ſo much water happens now and then to be left in it, that ſome is expreſſed together with the Oil: but as oil and water do not incorporate, they are eaſily ſeparated after the operation is finiſhed.

The extraction of the Oil is alſo greatly facilitated by heating the plates, between which the oleaginous matters are ſqueezed: but they muſt not be made too hot, if you mean to have a very mild Oil, deſigned either for aliment or for medicine; ſuch as the Oil of Olives, and that of ſweet almonds.

monds. For this reaſon the plates muſt be warmed in boiling water only: if you heat them to a greater degree, you run the riſk of giving an acrimony to the Oils you expreſs. But, when theſe Oils are intended for other uſes, the plates may be made hotter, becauſe their heat increaſes the yield of Oil.

It is remarkable, that all the Oils obtained by expreſſion, with the precautions above recommended, are conſtantly very mild; even though the matters from which they are extracted be in themſelves very acrid. Muſtard-ſeed, which is ſo acrid that it is even cauſtic, yields, by expreſſion, an Oil as mild as that of ſweet almonds. But then the kernels, ſeeds, and fruits, from which the Oils are extracted, muſt not be old; becauſe theſe Oils, which are perfectly mild when freſh and new, become intolerably acrid when they grow old, and acquire this acrimony even in the fruit itſelf; for it is obſerved that theſe fruits turn rancid as they grow old.

The Fat Oils obtained by expreſſion are uſed in medicine, both internally and externally, as Lenitives and Emollients. Every body knows the great uſe of Oil of ſweet Almonds, in inflammatory diſtempers of the breaſt and inteſtines. But it muſt be carefully noted, that theſe Oils can produce no good effects, unleſs they be freſh expreſſed, and from fruits, kernels, or ſeeds, that have not been long kept: for they not only loſe their lenient virtue by growing old, but they even acquire an oppoſite quality, and contract ſuch a ſharp acrimony, that far from procuring any ſalutary relief or mitigation to the inflamed parts, they are capable of irritating and inflaming the ſound.

It is therefore of the laſt importance to adminiſter them only when they are quite freſh: they ought never to be above two or three days old. Thoſe that are old are generally more limpid and tranſparent than the freſh, which look a little more cloudy. The beſt way to diſtinguiſh them is to taſte them, and to try whether or no they leave any ſenſation of rancidity on the palate and in the throat.

PROCESS III.

To draw the Eſſential Oils of certain Fruits by Expreſſion.

TAKE the rind of a Citron, Lemon, Orange, Bergamot-pear, or other fruit of that kind; cut it in ſlices, and, doubling the ſlices, ſqueeze them between your fingers, over againſt a poliſhed glaſs ſet upright, with its lower end in a veſſel of earth or porcelain. Every time you ſqueeze the peel in a new ply, there will ſquirt out of it ſeveral fine jets of liquor, which, meeting with the ſurface of the glaſs, will be condenſed into drops, and trickle down in ſmall ſtreams into the recipient. This liquor is the Eſſential Oil of the fruit.

OBSERVATIONS.

No fruits but thoſe of the kind above-mentioned will yield an eſſential Oil by expreſſion. The rind of the fruit is the reſervoir of this Oil: it is contained in little veſicles, which may be ſeen by the naked eye, ſpread all over the ſurface of the peel, and which, burſting when the peel is ſqueezed, diſcharge the Oil in the form of very fine ſlender ſpouts. Every body knows, that theſe little oily ſtreams inſtantly take fire, when ſpirted through the flame of a candle: the Oil in this caſe is entirely conſumed.

The Eſſential Oil, thus obtained by expreſſion, hath a very ſweet and moſt agreeable ſcent. It is in every reſpect the ſame as when it made a part of the fruit that yielded it, ſeeing it hath not undergone the action of fire. Yet this method, however good it may be, can hardly be practiſed but in the countries where thoſe fruits are in great plenty; becauſe we cannot by this means obtain any thing near the quantity of Oil they contain.

This inconvience may be remedied by rubbing the rind, which contains the Eſſential Oil, on the ſurface of a ſugar-loaf. The inequalities of that ſurface produce the effects of a raſp, by tearing all the oily veſicles. The Oil, which iſſues in abundance, is imbibed by the ſugar and moiſtens it. When the ſugar is ſufficiently impregnated therewith, it may be ſcraped off with a knife, and put into a well-ſtopped bottle. The ſugar does not alter the nature of the Oil; which may be kept in this manner for years, and uſed, though combined with the ſugar, for almoſt all the ſame purpoſes as when in a fluid ſtate; that is, to aromatize the ſeveral matters with which you incline to mix it. We owe theſe obſervations to Mr. Geoffroy.

This experiment, in which the Eſſential Oil of a vegetable is obtained by expreſſion alone, and without the aid of fire, proves that the Oils of this kind exiſt naturally in vegetables; and that the Oils of the ſame kind obtained by diſtillation, as ſhall be ſhewn in its place, are not the product of the fire. Eſſential Oils drawn by expreſſion do not very ſenſibly differ from thoſe procured by diſtillation.

CHAP.

CHAP. I.

Of the SUBSTANCES *obtained from* VEGETABLES *by* TRITURATION.

PROCESS I.

To make the Extract of a Plant by Trituration.

BRUISE the vegetable ſubſtance of which you intend to make the Extract; or, if it be hard and dry, grind it to a powder: put the matter thus prepared, together with ſeven or eight times as much rain-water, into an earthen veſſel; and into this veſſel fit a churning ſtaff, ſo that it may be continually whirled round with a rotatory motion, by means of a cord, a wheel, and a winch. Ply this machine for ten or twelve hours; and then filter the liquor through two linen cloths ſpread on a hair-ſieve. Let your filtered liquor ſtand quiet for twelve hours more: then pour it off by inclination from the ſediment you will find at bottom; and filter it a ſecond time through a flannel bag.

Pour freſh water, but in a ſmaller quantity, on the maſs left after trituration with the machine. Triturate it again for four or five hours. Treat the liquor of this ſecond triture juſt as you did that of the firſt, and mix them both together. Diſtribute all the liquor you now have among a ſufficient number of ſhallow earthen plates, and evaporate it by a gentle warmth, ſuch as that of the ſun, or of a vapour-bath, to the conſiſtence of an Extract, or even to dryneſs, as you think proper.

OBSERVATIONS.

IN trituration the water takes up, not only the Salts of plants, but alſo a pretty conſiderable quantity of their oily and earthy parts, which thoſe Salts have rendered ſoluble therein, by communicating to them a ſaponaceous and mucilaginous quality. After trituration, therefore, nothing remains but the groſſeſt particles of oil and earth. Hence it is evident, that the water, in which plants have been triturated, contains nearly the ſame principles as the juices of thoſe plants drawn by expreſſion; and that it is alſo impregnated with their Eſſential Salts: ſo that, by evaporating it to a due conſiſtence, we have a well made Extract of the triturated plant.

The Count de la Garaye, who hath long cultivated with great aſſiduity thoſe parts of Chymiſtry by which Medicine may be improved, hath made a great number of experiments for obtaining from plants, by triture with water, the matters in which their virtues chiefly reſide, and hath alſo publiſhed a work, entitled Hydraulic Chymiſtry, in which he gives a particular account of all the proceſſes for making ſuch Extracts of the chief mineral, vegetable, and animal ſubſtances, as are moſt frequently uſed in the Practice of Phyſic. His way of evaporating, by a gentle heat, the liquor containing the Extract of a triturated ſubſtance is a very good one: for we know that heat, if but a very little too ſtrong, is capable of changing the natures of compound bodies, by diſuniting their principles, and exhaling ſome of them.

If all vegetable matters were fat and ſucculent, as moſt pot-herbs are, triture would not be neceſſary for the making an Extract of them, even without the help of fire. We ſhould have nothing to do, for that purpoſe, but to expreſs their juices, as before, clarify them, and evaporate with a gentle heat to the conſiſtence of an Extract. But many vegetable ſubſtances, ſuch as woods, barks, roots, &c. are dry, hard, and compact. Theſe matters will not give out their Extract, without ſuch an application of water as ſhall diſſolve their ſaline, ſaponaceous, and mucilaginous parts. Now this muſt be effected either by triture or by fire. Trituration has the advantage of procuring Extracts, in which the principles are perfectly unaltered, and retain the ſame proportions, with reſpect to each other, as in the plant: but then it is attended with the inconveniencies of being very tedious, troubleſome, and chargeable. When we come to deliver the methods of making extracts by decoction and by infuſion, we ſhall ſee what are the advantages and diſadvantages of preparing Extracts by heat.

The matters, from which an extract is to be made by triture, muſt be previouſly bruiſed and reduced into ſmall parts, in order to facilitate the action of water upon them. The ſeveral filtrations and decantations here directed are intended to ſeparate the groſſer parts of the plant, that were only ſuſpended in the liquor, but not truly diſſolved, by means of the agitation and motion: for this reaſon alſo, the longer the liquor is left to ſettle, the purer will the Extract be.

Though the plant be triturated the firſt time with a great deal of water, and for a good while too, yet it is not by that means wholly exhauſted : M. de la Garaye therefore directs the remainder to be triturated again with freſh water: but this ſecond operation requires only half the water uſed in the former, and need be continued only half the time; the plant having been already opened by the former triture, and having fewer parts to give out. It is better to add freſh water, and triturate a ſecond time, than to triturate but once, and for a greater length of time: for when the water is impregnated with the principles of the plant to a certain degree, it is leſs capable of acting, and of diſſolving more, than when it is pure.

As the water impregnated with the principles of the plant by triture muſt be almoſt wholly evaporated, in order to bring thoſe principles nearer together, and that the whole may lie in the ſmalleſt compaſs poſſible; and, moreover, as this evaporation muſt be effected by the gentleſt heat, it is neceſſary to ſpread the liquor ſo, by diſtributing it among a great number of plates, that it ſhall be reduced in a manner entirely to ſurface. By this means the Extract may be evaporated even to dryneſs; and this is M. de la Garaye's practice. As the Extracts, thus evaporated to dryneſs, cannot be taken up otherwiſe than in little ſcales, the lower ſurfaces whereof, by adhering to the glazing of the plate, are ſmooth and ſhining, they in ſome meaſure reſemble a cryſtallized Salt; which led M. de la Garaye into an error, and induced him to give the title of Eſſential Salts to the Extracts prepared in this manner. The Eſſential Salt is indeed contained in them; but ſtill they are only Extracts, as Mr. Geoffroy hath ſhewn, in a memoir on this ſubject given in by him to the Academy; ſince, beſides the Eſſential Salt, they contain moreover, as was ſaid before, a great deal of the oil and earth of the matters from which they were extracted. This, in the main, is no objection, but rather an advantage to them; conſidering that ſuch ſaline Extracts are, on that account, ſo much the more like the ſubſtances from which they were obtained; eſpecially with regard to their medicinal properties.

PROCESS II.

To extract from Seeds and Kernels, by Trituration, the Matter of Emulſions.

BLANCH the kernels of which you deſire to make an Emulſion; put them into a marble mortar; add a very little water; and pound them with a wooden peſtle. Continue pounding and triturating till the matter become like a white paſte. From time to time pour on it, by little and little, more fair water warmed, ſtill continuing the trituration; by which means the paſte will grow thinner. Go on thus till every particle of your kernels be cruſhed to pap. Then add, ſtill rubbing the mixture, enough of water to make the whole an actual fluid; and you will have a liquor of a dead-white colour, reſembling milk. Strain it through a clean linen cloth; it will leave on the filter ſome coarſe parts, which muſt be returned to thoſe left in the mortar. Again triturate and rub the remainder of the kernels, with the addition of water as before. This ſecond liquor will not be ſo white nor ſo rich as the former: filter it in the ſame manner, and again grind with water the ſolid parts remaining. In this manner proceed, repeatedly rubbing and adding freſh water, till it appear no longer milky, but come off clear. The white milky waters thus obtained go by the name of an *Emulſion*.

OBSERVATIONS.

ALL the matters, from which a Fat Oil is obtainable by expreſſion, produce Emulſions when triturated with water.

An Emulſion conſiſts chiefly of two ſubſtances. One of theſe is mucilaginous, and ſoluble in water. This ſubſtance by itſelf would not give a milky appearance to the Emulſion, which, with it alone, would be limpid. The other is a Fat Oil, which of itſelf is not ſoluble in water; but being divided by the means of trituration into very ſmall globules, it is diſperſed through the whole liquor, and ſuſpended therein by the aid of the mucilaginous part. It is this oily part that gives the Emulſion its dead-white, milky colour; becauſe it is not actually diſſolved in the water, but only diffuſed through it.

If Oil be mixed with water in a phial, and the mixture ſtrongly ſhaken for ſome time, with a rapid and continued motion, the Oil will be divided into a vaſt number of little globules, which intervening between the parts of the water will deſtroy its tranſparency, and give it a dead-white colour, like that of our Emulſion. But, as the Oil is not ſo minutely divided by this means, as by triturating the matters containing it; and again, there being no mucilage in this liquor, as there is in Emulſions, the Oil ſoon ſeparates from the water when it is left at reſt, re-unites into round globules, and theſe joining together riſe to the ſurface of the liquor, which then recovers its tranſparency.

The caſe is not exactly the ſame with Emulſions; but ſomething like it happens to them alſo. If they be left to ſtand quiet in a long bottle, the liquor, which at firſt appeared homogeneous, ſeparates into two manifeſtly different parts. The upper part retains its dead-white colour, but is thicker and more opaque; while the lower part becomes perfectly tranſparent. This is the beginning of an entire ſeparation of the oily from the aqueous parts. The former, being the lighter, aſcend and gain the upper part of the liquor; while the lower, being freed from that which obſtructed its tranſlucence, recovers its proper limpidity: but the oily parts do not re-unite into maſſes large enough to form one homogeneous whole, with the appearance and limpidneſs of Oil; their being minutely divided and entangled in the mucilage impeding their natural tendency.

Emulſions firſt begin to ſpoil, as they grow old, not by turning rancid and acrimonious like the Fat Oils drawn by expreſſion, but by turning ſour; which is owing to the great quantity of mucilage they contain. As there is a Fat Oil in their compoſition, they have the ſame virtues with that ſort of Oil; but they are, moreover, incraſſating, cooling, and emollient; qualities which render them extremely uſeful in acute and inflammatory diſorders. They grow ſour in a very ſhort time, eſpecially in the heat of ſummer; nay, they ſometimes do ſo in two hours: and therefore they ought to be prepared from time to time as they are to be uſed.

The matter that is left when all the ſubſtance of the Emulſion is extracted, and from which the water comes off clear and limpid, is ſcarce any thing but the earthy part of the ſeed or kernel that was triturated; which, however, ſtill retains a portion of tenacious and groſs Oil, adhering to it ſo firmly as not to be ſeparable by water.

The chyle and milk of animals reſemble an Emulſion in ſeveral reſpects, and particularly in their dead-white colour; which ariſes, in the ſame manner, from the very minute particles of Oil contained in them, and diſtributed through an aqueous gelatinous fluid, but not diſſolved therein. In general, whenever any Oil of any kind happens to be lodged in this manner between the parts of an aqueous liquor, it always makes the whole of an opaque white: for Oil will not mix with water, ſo as to produce a liquor that ſhall appear homogeneous and tranſparent, unleſs it be intimately diſſolved in the water; which cannot be effected but by means of an union previouſly contracted between it and ſome ſaline matter: as is the caſe of mucilages, certain ſaponaceous matters, and ſome other combinations of which we ſhall have occaſion to treat in the ſequel.

The methods we have hitherto propoſed, for extracting from vegetable ſubſtances all that they will yield without the aſſiſtance of fire, are not capable of analyzing thoſe ſubſtances accurately, as you may have obſerved; ſince by expreſſion and trituration we obtain only the liquid parts, impregnated indeed with almoſt all the principles of plants, which, however are ſtill combined with each other, and barely ſeparated from the groſſeſt earthy and oily parts. We muſt therefore neceſſarily have recourſe to a more effectual expedient for carrying our analyſis further. This expedient conſiſts in making them undergo the action of fire, ſucceſſively graduated, from the gentleſt to the moſt violent heat.

But, before we enter on this Analyſis of Vegetables, it is proper to deſcribe the different operations that may be performed on Oils, the only pure principle we have been able to obtain without the help of fire. As we ſhall have occaſion, when we come to treat of the analyſis of plants by fire, to ſay a great deal more concerning Eſſential Oils, we reſerve till then what relates to the operations that may be performed on them; and confine ourſelves here to the operations on Fat Oils.

CHAP. III.

Of OPERATIONS *on* FAT OILS.

PROCESS I.

To attenuate Fat Oils, and change their Nature, by expoſing them to the Action of Fire, and diſtilling them.

MIX thoroughly three or four pounds of any Fat Oil whatever, with twice its weight of lime ſlaked in the air. Put this mixture into a large earthen retort, leaving a third part of it empty. Set it in a reverberating furnace, and lute on a receiver. Heat the veſſel with a very gentle fire. A little phlegm will riſe firſt, and will ſoon be followed by an Oil that will fall in drops from the noſe of the retort. Continue the diſtillation very ſlowly, till you perceive the Oil that comes over begin to be not quite ſo fluid as before, but rather a little thicker.

Then unlute your receiver, and put another in its place. Continue the diſtillation, increaſing your fire by degrees. The Oil that comes over will grow thicker and thicker, its fluidity will decreaſe, and it will acquire a dark-brown colour, which at laſt will become blackiſh. The Oil will then be very thick. Puſh the operation till nothing more will come off, though the retort be red-hot. During the whole time this diſtillation laſts, there riſes a good deal of water, in company with the Oil. Keep the ſecond thick Oil by itſelf.

Mix the Oil that came over firſt, in this operation, with an equal part of freſh lime ſlaked in the air. Put the mixture into an earthen or glaſs retort, of a ſize ſo proportioned to the quantity, that a third part thereof may remain empty. Diſtil as before. The ſame phenomena will appear: a clear Oil will firſt come over, and be ſucceeded by one a little thicker. Then ſhift your receiver, and diſtil off all the reſt of the Oil with an increaſed fire. The firſt Oil obtained by this ſecond diſtillation will be clearer and thinner than that of the firſt diſtillation; and the ſecond Oil will not be ſo thick, nor of ſo deep a colour as before.

Diſtil over again, in the ſame manner, the thin Oil of this ſecond diſtillation, and go on thus repeatedly diſtilling, till the firſt clear oil come over with a degree of heat not exceeding that of boiling water. Then, inſtead of mixing your Oil with lime, put it with ſome water into a glaſs retort, or into a body with its head fitted on, and diſtil it, keeping the water juſt in a ſimmer. Your Oil will be more and more attenuated, and, after being thus diſtilled twice or thrice with water, will be ſo limpid, ſo thin, and ſo clear, that you will ſcarce be able to diſtinguiſh it from water itſelf.

OBSERVATIONS.

Fat Oils, which are naturally mild, unctuous, inodorous, or have at moſt a ſcarce perceptible ſmell, reſembling that of the fruit or kernel from which they were extracted, change their natures totally when expoſed to the action of fire. If they be but heated ſo as to boil, they become acrid, loſe much of their unctuoſity, and acquire a very pungent odour. From ſeveral analogies, and by ſeveral experiments, recited in a Memoir on Oils which I read to the Academy, I ſhewed that theſe alterations of Fat Oils are produced by the fire's extricating an Acid in them, which before lay concealed and inactive. What I advanced on this ſubject may be ſeen in the Memoirs of the Academy for 1745, and in my Elements of the Theory of Chymiſtry. I ſhall take occaſion to add ſomething more, in my Obſervations on the following proceſs, by which theſe Oils are combined with Acids. In this place I ſhall only examine what paſſes in the repeated diſtillations they are here made to undergo.

Fat Oils do not riſe in diſtillation without a degree of heat greater than that of boiling water; and therefore they muſt be diſtilled in a ſand-bath, or with a naked fire. We prefer the latter method, for reaſons elſewhere aſſigned, and chiefly becauſe the operator is more maſter of his fire; it being abſolutely neceſſary, in this operation, that he have it in his power to ſuppreſs it in an inſtant, when he finds it too ſtrong: for, in ſuch a caſe, it will impetuouſly raiſe the thin Oil mixed with the thick; nay, the whole will be burnt, as it were, to a coal, if a degree of fire ever ſo little too ſtrong be kept up but for a few moments. When this accident happens, it is always predicted by a great quantity of white vapours aſcending with impetuoſity out of the retort, and by drops of Oil following each other very faſt, that are ſcarce limpid at firſt, and ſoon become of a dark colour. All this may be prevented by diſtilling very ſlowly, and with great patience.

Fat Oils may be diſtilled and attenuated without any additament: but then the operation, which is tedious and troubleſome enough, even when lime is uſed, as appears from our deſcription of the proceſs, would be much more ſo if the Oil were diſtilled alone, without the addition of any thing to divide it, ſpread it, and enlarge its ſurface.

Lime is one of the beſt additaments that can be employed on this occaſion; not only becauſe it procures the advantages juſt mentioned, but alſo by reaſon that, being an abſorbent of fat matters, it unites with the groſſer parts of the Oil, retains them, and ſo allows the thinneſt and lighteſt parts to be readily ſeparated from the reſt. By this means it greatly expedites the operation: and, the more of it is added, with reſpect to the oil, the ſooner is a conſiderable quantity of thin limpid Oil obtained: and this is the reaſon of our directing a double quantity of lime to be mixed with the Oil in the firſt diſtillation.

Lime ſlaked in the air is employed preferably to quick-lime; becauſe it is naturally divided into a very fine powder, and capable of mixing perfectly with all ſorts of matters.

The water that firſt appears in the diſtillation comes from the lime: it is part of the humidity which the lime had imbibed from the air. This water continues to riſe with the Oil during the whole diſtillation, according as the degree of heat is increaſed: and, if the diſtillation be finiſhed by keeping the retort red-hot for ſome time after all is come over, the lime in it will have a greyiſh caſt, and, when water is poured on it, grow almoſt as hot as quick-lime.

If you reſolve to carry on theſe diſtillations of a Fat Oil, till it becomes as light as an Eſſential Oil, it is neceſſary to begin with a pretty large quantity thereof, as three or four pounds: for the quantity of the Oil is conſiderably leſſened by every diſtillation; not only becauſe the thickeſt and groſſeſt part is ſeparated from it every time; but alſo becauſe a portion of the Oil remains ſo ſtrongly united with the lime, that the force of fire is not able to ſeparate them. Moreover, there is reaſon to believe that ſome of it is decompoſed every time it is diſtilled.

If Oil be diſtilled by itſelf, the thickeſt and heavieſt part remains charred, as it were, in the retort, the inſide of which is lined with a cruſt of coal, that is to the laſt degree fixed: this therefore always occaſions a diminution of the Oil.

A Fat Oil muſt be diſtilled eight or nine times, even with lime, before it become as light as an Eſſential Oil, and capable of riſing wholly with the heat of boiling water: by that time therefore it muſt be conſiderably diminiſhed; and if, at leaſt, the quantity preſcribed be not taken at firſt, there will ſcarce remain a few ounces capable of being diſtilled with water.

The portion of thick heavy Oil, obtained in the ſeveral diſtillations, may, if you will, be rectified again. For this purpoſe you muſt mix it with freſh lime, and diſtil it as you did the clear Oil. A portion of this alſo will be attenuated, and come over firſt. Thus all the Fat Oil may be ſubtilized by the action of fire; an abſolutely charred black part excepted, that remains fixed, and appears ſuſceptible of no change, but by burning it in the open air, and thereby reducing it to aſhes, from which a little Fixed Alkali may be obtained. In this fixed part of the Oil the acid and earthy parts are combined therewith, in a greater proportion than they ought to be in pure Oil.

The portion of Oil that hath become light and thin is nothing but the pureſt oily part, ſeparated from the groſs acids, and from a certain quantity of earth, which made it thick and heavy. This Oil reſembles the Eſſential Oils in lightneſs, fluidity, and a penetrating agreeable odour: it diſſolves in Spirit of Wine. We ſhall have occaſion in the ſequel to enlarge further on the qualities of the ſeveral ſorts of Oils, and their ſolubility in Spirit of Wine, when we come to treat of Ardent Spirits and of Æther.

PROCESS II.

To combine Fat Oils with Acids. The Decompoſition of this Combination.

PUT any Fat Oil whatever into a glaſs baſon, and ſet it in a ſand-bath very moderately heated. Pour on this Oil an equal quantity of concentrated Oil of Vitriol, which will immediately diſſolve it with violence; a conſiderable ebullition and effervеſcence will ariſe, attended with great heat, and a prodigious quantity of black, thick vapours, in which may be eaſily perceived the ſmell of burnt Oil, together with that of a Sulphureous Acid. The mixture will become of a deep-red, black, and thick. Stir it with a ſmall ſtick, till you obſerve that all is quiet.

OBSER-

OBSERVATIONS.

The Vitriolic and Nitrous Acids unite with Fat Oils, and diſſolve them with violence; but theſe Acids muſt be ſufficiently ſtrong and concentrated, otherwiſe they will not act upon the Oils. The Vitriolic Acid, in particular, diſſolves them pretty thoroughly. If hot water be poured on the mixture deſcribed in our proceſs, this water will become cloudy and milky, by diſſolving ſome of it: ſo that Oils may be rendered ſoluble in water by the means of Acids. Spirit of Wine, which doth not attack Fat Oils in their natural ſtate, unites perfectly with them, and makes a clear limpid ſolution of them, when they are thus combined with Acids.

The Acids alſo ſuffer a conſiderable alteration by contracting an union with Oils. They become much milder, and loſe almoſt all their ſtrength. If the mixture deſcribed in the proceſs be diſtilled, there will come over a great quantity of an empyreumatic acidulated phlegm, that ſmells ſtrong of Sulphureous Spirit; an Oil thinner than the original ſaponaceous mixture; a weak Oily Acid, and a very thick, black Oil. If the fire be made very ſtrong, when the Oil ceaſes to riſe, it ſometimes happens that a little Sulphur ſublimes into the neck of the retort.

By this analyſis it appears, that the ſtrong concentrated Acid, which was an ingredient in the combination, is not now to be found. The Vitriolic Acid hath changed its nature, and is conſiderably weakened by the union it hath contracted with the principles of the Oil. The aqueous part of this latter ſubſtance weakens the other, and loads it with phlegm; the inflammable part thereof renders it ſulphureous, and even converts it into Sulphur.

Hence it follows, that ſame part of the Oil is decompoſed, by the union it contracts with the Vitriolic Acid; for its phlogiſton and its aqueous principle cannot be diſunited, ſo as to form a Sulphureous Spirit, or an actual Sulphur, and an aqueous Acid, without the decompoſition of a certain quantity of the Oil, in proportion to the two disjoined principles. Another portion of the Oil remains united with the Vitriolic Acid, without ſuffering any decompoſition, and communicates to that portion of the Acid, with which it is combined, a ſomewhat ſaponaceous quality, which makes it reſemble the Vegetable Acids.

Thus we ſee, that when the Vitriolic Acid and a Fat Oil are combined together, they both ſuffer conſiderable changes; the Acid by the new alliances into which it enters, and the

Oil by the decompoſition it undergoes. In conſequence hereof a much ſmaller quantity of Oil is obtained, by decompounding this combination, than was at firſt put in.

If the Oil abſtracted by diſtillation be combined again with a freſh quantity of the concentrated Acid, the ſame effects will again follow; and by this means any quantity of Oil at pleaſure may be entirely decompoſed. This ſingle experiment affords an evident proof of many important truths advanced in our Elements of the Theory.

Spirit of Nitre likewiſe diſſolves expreſſed Oils. With Oil of Olives it forms a white paſte, reſembling a fine pomatum. This compound is perfectly ſoluble in Spirit of Wine. The Acid muſt be very ſtrong and ſmoking to unite with this, or with any other Fat Oil: but it diſſolves ſome of them with more rapidity than others; in which number is the Oil of Walnuts. It acts on theſe Oils with ſo much vehemence that it burns them, in ſome meaſure, making them black and thick.

PROCESS III.

To combine Fat Oils with Fixed Alkalis. Hard and ſoft Soap. The Decompoſition of Soap.

TAKE a lixivium of Alicant kelp made more cauſtic by lime, as we ſhall ſhew when we come to ſpeak of Alkalis. Evaporate this lye till it be capable of bearing a new-laid egg. Divide it into two parts; and to one of theſe put juſt water enough to weaken it ſo, that a new-laid egg will not ſwim in it, but fall to the bottom. With the lye thus weakened mix an equal quantity of freſh-drawn Olive Oil. Stir and agitate the mixture well, till it become very white. Set it over a gentle fire, and continue ſtirring it inceſſantly, that the two ingredients of which it is compounded may gradually combine together, as part of the water evaporates. When you perceive they begin to unite, pour into the mixture thrice as much of the firſt ſtrong lye as you took of Olive Oil. Continue the coction with a gentle fire, always ſtirring the matter, till it becomes ſo thick that a drop of it fixes, as it cools, into the conſiſtence that Soap ought to have. By diſſolving a little of this Soap in water, you will diſcover whether or no it contains more Oil than ought to be in the compoſition. If it diſſolves therein wholly and perfectly, without the appearance of the leaſt little drop of Oil floating on the water, it is a ſign that it doth not contain too much Oil. If, on the contrary, you perceive any of theſe little globules, you muſt pour into the veſſel, containing your matter, a little more of the ſtrong lye, to abſorb the redundant Oil. If there be too much of the Alkali it may be diſcovered by the taſte. If the Soap leave on your tongue the ſenſation of an Alkaline Salt, and produce an urinous ſavour, it is a ſign that there is too much Salt in proportion to the Oil. In this caſe a little Oil muſt be added to the mixture, to ſaturate the ſuper-abundant Alkali. An exceſs in the quantity of Alkali diſcovers itſelf likewiſe by the Soap's growing moiſt in the air, on being expoſed to it for ſome time.

OBSERVATIONS.

FIXED Alkalis, even when reſolved into a liquor, that is, when loaded with much water, unite eaſily with Fat Oils, as appears from the experiment juſt recited, and require but a moderate heat to perfect that union. This combination may even be completely effected without the aid of fire, and by the heat of the ſun only, provided ſufficient time be allowed for that purpoſe; as Mr. Geoffroy found upon trial. It only requires the mixture of the Oil and Alkali to be kept five or ſix days in digeſtion, and ſtirred from time to time. A lixivium of pure Alkali, not acuated by lime, may alſo be uſed to make Soap: but it is obſerved, that the combination ſucceeds better, and that the Alkali unites ſooner and more perfectly with the Oil, when it is ſharpened by lime.

The Oil is firſt mixed with a weaker and more aqueous lye, to the end that the combination may not take place too haſtily, but that all the particles of the two ſubſtances to be compounded together may unite equally. But as ſoon as the Alkali begins to diſſolve the Oil gradually and quietly, the diſſolution may then be accelerated; and that is done by adding the remaining lye, which is ſtronger and leſs diluted than the other.

Soap made with Olive Oil is white, hard, and hath not a very diſagreeable ſmell: but as that Oil is dear, others, even the fat and oils of animals, are ſometimes ſubſtituted for it. The Soaps made with moſt of theſe other matters are neither ſo hard, nor ſo white, as that made of Olive Oil: they are called *Soft Soaps*.

Oils thus aſſociated with Fixed Alkalis are by that means rendered ſoluble in water; becauſe the Alkaline Salts, having a great affinity with water, communicate part thereof to the

Oils with which they are now incorporated. Yet the Oil is not for all that rendered thoroughly miſcible with water, or perfectly ſoluble therein; for the water in which Soap is diſſolved hath always a milky caſt: now there is no other criterion of a perfect ſolution but tranſparency.

Alkalis alſo loſe part of their affinity with water, by the union they thus contract with Oils: for, when the combination is properly made, they no longer attract the moiſture of the air, nor doth water diſſolve them in ſuch quantities as before. The compoſition of Soap is plainly a ſaturation of an Alkali with an Oil; and, in order to make perfect Soap, we are forced, as was ſaid in the proceſs, to grope, in a manner, by repeated trials, for this point of ſaturation; juſt as when we prepare a Neutral Salt by ſaturating an Alkali with an Acid. The union which the Oil contracts with the Alkali makes it loſe, in part, the readineſs with which it naturally takes fire; becauſe the Salt is not inflammable: the water alſo, which enters in pretty conſiderable quantities into the compoſition of Soap, as we ſhall preſently ſee, contributes a good deal to hinder the accenſion of the Oil.

Soap may be decompounded either by diſtilling it, or by mixing it with ſome ſubſtance that hath a greater affinity than Oil with Alkalis.

If we decompound it by diſtillation, a phlegm, or tranſparent ſpirit, of a ſomewhat yellowiſh colour, firſt comes over. This liquor is the aqueous part of the Soap, quickened by a little of its Alkali, which gives it an acrid taſte. It is followed by a red Oil, which at firſt is pretty thin and limpid, but thickens as the diſtillation advances, grows black, and has a very diſagreeable empyreumatic ſmell. This Oil is ſoluble in Spirit of Wine.

When the diſtillation is finiſhed, that is, when the retort being kept red-hot for ſome time will diſcharge no more, there is left in it a ſaline maſs; which is the Alkali of the Soap, cruſted over with ſome of the moſt fixed parts of the Oil, that are charred to a coal. This Salt may be reſtored to the ſame degree of purity it had before its combination with the Oil, by calcining it in a crucible with a naked fire, that may conſume this burnt part of the Oil, and reduce it to aſhes.

It is plain that the Oil contained in Soap is affected by diſtillation, much in the ſame manner as that which we mixed with lime and diſtilled.

Mr. Geoffroy, by analyſing Soap with care, diſcovered that two ounces thereof contain ninety-ſix grains of Salt of kelp, freed from all Oil and moiſture; or two drams and forty-eight grains of that Salt, as it is uſed in manufacturing Soap; that is, containing water enough to make it cryſtallize; one ounce three drams twenty grains of Olive Oil; and about two drams four grains of water.

As Acids have a greater affinity than any other ſubſtance with Alkalis, they may be very effectually employed to decompound Soap.

If you propoſe to decompound Soap by means thereof, you muſt firſt diſſolve it in a ſufficient quantity of water. Mr. Geoffroy, who made this experiment likewiſe, diſſolved two ounces thereof in about three gallons of warm water, and to the ſolution added Oil of Vitriol, which he let fall into it drop by drop. Every time a drop of Acid falls into it, a *coagulum* is formed in the liquor. The veſſel in which the ſolution is contained muſt then be ſhaken, that the Acid may equally attack all the Alkali diffuſed in it. When no new coagulation is produced by a drop of the Acid, it is a ſign you have added enough. The liquor then begins to grow clear: and if another quart of water be added, in order to facilitate the ſeparation of the oily particles, you will ſee them riſe and unite together on the ſurface of the liquor.

This is a pure, clear, true Olive Oil, hath its taſte, its ſmell, and, like it, is fluid in warm weather, and becomes fixed by cold. Yet it differs in ſome reſpects from that which never hath been united with an Alkali in order to form a Soap; for it burns more vividly and more rapidly, and is ſoluble in Spirit of Wine. We ſhall account for theſe differences when we come to treat of Ardent Spirits.

Not only the Vitriolic Acid, but all others, even thoſe obtained from vegetables, are capable of decompounding Soap, and ſeparating the Oil from the Alkali. In the liquor wherein Soap is thus decompounded is found a Neutral Salt, conſiſting of the Acid made uſe of, united with the Alkali of the Soap. If the Vitriolic Acid be uſed, you will have a Glauber's Salt; a quadrangular Nitre, if the Nitrous Acid be uſed; and ſo of the reſt.

The facility with which Acids decompound Soap is the reaſon that no water, but what is very pure, will diſſolve it, or is fit to be uſed in waſhing with it.

Water that doth not diſſolve Soap well is uſually called *Hard Water*. Such waters contain a certain quantity of ſaline matters, waſhed out of the earths through which they paſs. The hardneſs of water is generally occaſioned by ſelenitic particles.

The hardneſs of all the well-water in and about Paris is owing to a conſiderable quantity of Selenetic Gypſum with which the Soil abounds. The Selenites, we know, are Neutral Salts, conſiſting of the Vitriolic Acid united with an earthy baſis. If therefore Soap be put into water in which a Salt of this kind is diſſolved, it is evident that the Vitriolic Acid in the Selenites, having a greater affinity with the fixed Alkali of the Soap than with its own earthy baſis, will quit the latter to unite with the former; and thus the Soap will be decompounded inſtead of being diſſolved. Accordingly we ſee, that, when we attempt to diſſolve Soap in our well-water, the ſurface of the liquor is in a ſhort time covered with a fat oily pellicle. However, this decompoſition of Soap is not complete; at leaſt, but a ſmall part of it is perfectly decompounded; becauſe the great quantity of Selenites, with which the water is impregnated, hinders the Soap from mixing ſo thoroughly with it, as is requiſite to produce a total decompoſition thereof.

All mineral waters are likewiſe hard, with regard to Soap; for as moſt of them owe their virtues to the effloreſcences they have waſhed off from pyrites, that have grown hot and begun to be decompoſed, they are impregnated with the ſaline matters produced by pyrites in that ſtate: that is, with aluminous, vitriolic, and ſulphureous ſubſtances, which have the ſame effect on Soap as the Selenites have.

Mineral waters containing Neutral Salts only, ſuch as Sea-ſalt, Epſom Salt, Glauber's Salt, are nevertheleſs hard with regard to Soap, though the Acids of thoſe Salts, being united with Fixed Alkalis, are incapable of decompounding it. The reaſon is, that thoſe Neutral Salts are more ſoluble in water than Soap is; ſo much indeed as even to exclude it: becauſe each of the two principles that compoſed them hath a very great affinity with water; whereas only one of the principles of Soap, namely, its Alkali, hath that affinity; the other, to wit, the oily principle, having none at all. Thus water impregnated with an Acid, or with any Neutral Salt, is hard with regard to Soap, and incapable of diſſolving it; and hence it follows, that Soap is a ſort of touchſtone for trying the purity of water.

Wine diſſolves Soap; but imperfectly, becauſe it contains an acid or tartarous part. Spirit of Wine alſo diſſolves it: but neither is this diſſolution perfect; becauſe it contains too little water: for its ſpirituous part can diſſolve nothing but the Oil of the Soap; and the Alkali is not at all, or at leaſt in a very ſmall quantity, ſoluble in this menſtruum. The true ſolvent of Soap is therefore a liquor that is partly ſpirituous, partly aqueous, and not acid.

Brandy has theſe qualities: and accordingly it is the ſolvent that unites beſt with Soap, diſſolves the greateſt quantity, and makes the moſt limpid ſolution thereof. Yet even this ſolution hath ſomething of a milky caſt, occaſioned by its not being entirely free from an Acid, or the tartarous principle. This fault may be eaſily corrected, by mixing with it a little Alkali to abſorb the Acid. A dram of cryſtallized ſalt of kelp mixed with three ounces and a half of good brandy, renders it capable of diſſolving an ounce and two drams of good hard Soap, into a perfectly limpid liquor. This experiment alſo we owe to Mr. Geoffroy.

Some years ago it was diſcovered that Soap might be uſed with great ſucceſs in Medicine, and that it poſſeſſes the property of diſſolving the ſtony concretions that form in ſeveral parts of the body, particularly in the kidneys and bladder. Soap is the baſis of the compoſition known by the name of *Mrs. Stephen's Remedy*, and in this one ingredient its whole virtue reſides.

From what hath been ſaid on the nature of this compound, as well as on the cauſe and phenomena of its diſſolution, it plainly appears to be of the laſt conſequence, in adminiſtering it to a patient, that his conſtitution be conſidered, and a proper regimen ordered. All Acids ſhould be abſolutely forbid him; as we know they hinder the Soap from diſſolving, and decompound it; and if the patient have any acidities in the firſt paſſages, matters capable of neutralizing them ſhould be preſcribed him: as prepared crabs eyes, and other abſorbents known in Medicine: in ſuch caſes thoſe with which the Soap is compounded in Mrs. Stephen's remedy may be of uſe.

PROCESS IV.

To combine Fat Oils with Sulphur.

PUT any Fat Oil whatever into an earthen veſſel; add to it about the fourth part of its weight of Flower of Sulphur, and ſet the veſſel in a furnace, with lighted coals under it. When the Oil hath acquired a certain degree of heat, the Sulphur will melt, and you will ſee it fall immediately to the bottom of the Oil, in the form of a very red fluid. The two ſubſtances will remain thus ſeparated, without mixing

ing together, while the heat is no greater than is neceſſary to keep the Sulphur in fuſion. Increaſe it therefore; but ſlowly and with circumſpection, leſt the matter take fire. When the Oil begins to ſmoke, the two liquors will begin to mix and look turbid: at laſt they will unite ſo as to appear one homogeneous whole. If you keep up the heat ſo that the mixture ſhall always continue ſmoking and ready to boil, you may add more Sulphur, which will perfectly incorporate with it: and thus may a pretty conſiderable quantity thereof be introduced into this compoſition.

OBSERVATIONS.

THE Phlogiſton and the Vitriolic Acid have each an affinity with Oils. It is not therefore ſurpriſing that Sulphur, which is a compound of theſe two ſubſtances, ſhould be ſoluble in oily matters. Yet it is remarkable, that Eſſential Oils, which are much thinner than the Fat Oils, diſſolve Sulphur with much more difficulty; as will be ſhewn when we come to treat of thoſe Oils; and that Spirit of Wine, which contains an exceeding ſubtile Oil, doth not act upon Sulphur at all.

Oil, by contracting an union with Sulphur, produces a conſiderable alteration in that mineral: a phenomenon ſo much the more ſurpriſing, that we know it to be in ſome ſort unalterable by any other ſolvent, of what kind ſoever, add, that its nature admits of no change but by burning. We ſhall ſay more on this ſubject under the head of Eſſential Oils.

PROCESS V.

To combine Fat Oils with Lead, and the Calces of Lead. The Baſis of Plaſters. The Decompoſition of this Combination.

INTO an earthen veſſel put granulated Lead, Litharge, Ceruſe, or Minium; and pour thereon twice its weight of any Fat Oil whatever. If you ſet the veſſel over a briſk fire, the Lead at bottom will melt before the Oil begin to boil. When it boils, ſtir the matter with a ſtick: the Lead, or the Calx of Lead, will gradually diſappear, and at laſt be totally diſſolved by the Oil, to which it will give a very thick conſiſtence.

OBSERVATIONS.

Fat Oils diſſolve not only Lead, but its calces alſo: nay, they diſſolve the latter more readily than Lead in ſubſtance; probably becauſe they are more divided. The reſult of a combination of theſe matters is a thick, tenacious maſs, that grows in ſome degree hard in the cold, and ſoft by heat. This compoſition is known in Pharmacy by the name of *Plaſter*. It is made up with ſeveral drugs into plaſters, which partake of the virtues of thoſe drugs; ſo that it is the baſis of almoſt all plaſters.

Lead itſelf is ſeldom uſed to make plaſters: Ceruſe, Litharge, or Minium, are preferred to it; becauſe theſe matters unite, as hath been ſaid, more readily and more eaſily with Oils.

It ſometimes happens, that the Oil is burnt in the operation, and that the calx of Lead is partly reſuſcitated: and this gives the plaſter a black colour, which however it ought not to have. This accident is occaſioned by an exceſs of heat: and as it is very difficult to keep the Oil and the Lead in the proper degree of heat, ſeeing both theſe matters are apt to grow very hot, it hath been contrived to put into the veſſel, in which the coction is to be performed, a pretty large quantity of water; which being ſuſceptible only of a much ſmaller and a certain degree of heat, that is conſtantly the ſame when it boils, procures the advantage of having the compoſition very uniform and very white.

It is neceſſary to ſtir the mixture inceſſantly, in order to prevent the burning of the combined Oil and Lead; which, as they unite, ſink in the water by their greater weight. If the water happen to be waſted before the Oil hath diſſolved all the Lead, or before the plaſter hath acquired a proper degree of conſiſtence, you muſt remove the veſſel from the fire, and let the mixture cool, before you add more: for, if this precaution be neglected, the heat of the matter, which is now much greater than that of boiling water, will occaſion a conſiderable exploſion and extravaſation thereof, though the water poured into it be as hot as poſſible.

The combination of Fat Oil with a Calx of Lead may be conſidered as a ſort of metallic Soap, having a metalline Calx, inſtead of a Fixed Alkali, for its baſis. Mr. Geoffroy hath obſerved, that if a pound of Litharge, rubbed very fine and well waſhed, be incorporated with two pounds of Olive Oil, in the ſame manner as plaſter is made, keeping water enough in the veſſel to hinder the mixture from burning, there riſes a ſmoke, while the Oil is uniting with the Calx of Lead, ſmelling much like that which riſes from Soap.

The Oil may be ſeparated from the Calx of Lead, by the methods uſed to ſeparate it from a Fixed Alkali: and when it is ſo ſeparated, it hath the ſame properties as that ſeparated from common Soap.

This ſpecies of metallic Soap, formed by the union of a Fat Oil with the Calx of Lead, is not ſoluble in water, and communicates nothing to it but a greaſy taſte. Therefore, if you would decompound it by the means of an Acid, you muſt pour that Acid immediately on the compound. The Acid will attack and diſſolve the Calx of Lead; and the Oil, being thus ſet at liberty, will riſe clear and limpid to the ſurface of the acid liquor. Diſtilled vinegar effects this ſeparation better than any other Acid, becauſe it is the true ſolvent of Lead.

CHAP. IV.

Of the SUBSTANCES *obtained from* VEGETABLES *with a Degree of Heat not exceeding that of boiling Water.*

PROCESS I.

To obtain from Plants, by diſtilling them with the mean Degree of Heat between freezing and boiling Water, a Liquor impregnated with their Principle of Odour.

IN the morning, before ſun-riſe, gather the plant from which you deſign to extract its odoriferous water. Chuſe the plant in its full vigour, perfectly ſound, and free from all adventitious matters, except dew. Put this plant, without ſqueezing it, into the body of a tinned copper alembic, and ſet it in a water-bath. Fit on its head, and to the noſe thereof lute a glaſs receiver with wet bladder.

Warm the bath to the mean degree between freezing and boiling water. You will ſee a liquor diſtil and fall drop by drop into the receiver. Continue the diſtillation with this degree of heat, till no more drops fall from the noſe of the alembic. Then unlute the veſſels; and if you have not as much liquor as you want, take out of the cucurbit the plant already diſtilled, and put a freſh one in its place. Diſtil as before, and go on thus till you have a ſufficient quantity of odoriferous liquor. Put it into a bottle; ſtop it cloſe; and ſet it in a cool place.

OBSERVATIONS.

THE liquor obtained from plants, with the degree of heat here preſcribed, conſiſts of the dew that was on the plant, and ſome of the phlegm of the plant itſelf, together with its odorous principle. Mr. Boerhaave, who examined this odoriferous part of plants with great care, calls it the *Spiritus Rector*. The nature of this Spirit is not yet thoroughly aſcertained; becauſe it is ſo very volatile, that it cannot eaſily be ſubjected to the experiments that are neceſſary to analyze it, and to diſcover all its properties. If the bottle containing the liquor, which may be conſidered as the vehicle of this Spirit, be not exceeding carefully ſtopped, it flies quite off: ſo that in a few days nothing will be found but an inſipid inodorous water.

Great part of the virtue of plants reſides in this their principle of odour; and to it muſt be aſcribed the moſt ſingular and the moſt wonderful effects we every day ſee produced by them. Every body knows, that a great number of odorous plants affect, in a particular manner, by their ſcent only, the brain and the *genus nervoſum*, of ſuch eſpecially whoſe nerves are very ſenſible, and ſuſceptible of the ſlighteſt impreſſion; ſuch as hypochondriacal or melancholy men, and hyſterical women. The ſmell of the Tuberoſe, for inſtance, is capable of throwing ſuch perſons into fits, ſo as to make them drop down and ſwoon away. The ſmell of Rue, again, which is equally ſtrong and penetrating, but of a different kind, is a ſpecific remedy againſt the ill effects of the Tuberoſe; and brings thoſe perſons to life again, with as quick and as ſurpriſing an efficacy, as that by which they were reduced to a ſtate not unlike death. This is Mr. Boerhaave's obſervation.

The odorous exhalations of plants muſt be conſidered as a continual emanation of their *Spiritus Rector*: but as growing plants are in a condition to repair, every inſtant, the loſſes they ſuſtain by this means, as well as by tranſpiration, it is not ſurpriſing that they are not ſoon exhauſted, while they continue in vigour. Thoſe, on the contrary, which we diſtil, having no ſuch reſource, are very ſoon entirely deprived of this principle.

The ſeparation of the *Spiritus Rector* from plants requires but a very gentle heat, equally diſtant from the freezing point and from the heat of boiling water. Accordingly the heat of the ſun in ſummer is ſufficient to diſſipate it almoſt entirely. This ſhews why it is dangerous to ſtay long in fields, or woods, where many noxious plants grow. The virtues of plants reſiding chiefly in their exhalations, which the heat of the ſun increaſes conſiderably, a ſort of atmoſphere is formed round them, and carried by the air and the wind to very great diſtances.

For the ſame reaſon the air of a country may be rendered ſalutary and medicinal, by the exhalations of wholeſome plants growing therein. From the facility with which the odorous principle of plants evaporates, we learn what care ought to be taken in drying thoſe intended for medical uſes, ſo as to preſerve their virtues. They muſt by no means be expoſed to the ſun, or laid in a warm place: a cool, dry place, into which the rays of the ſun never penetrate, is the propereſt for drying plants, with as little loſs of their virtue as poſſible.

Though there is reaſon to believe that every vegetable matter hath a *Spiritus Rector*, ſeeing each hath its particular ſcent, yet this principle is not very perceptible in any but thoſe which have a very manifeſt odour: and accordingly it is extracted chiefly from aromatic plants, or the moſt odoriferous parts of plants. I ſay the moſt odoriferous parts; becauſe, in moſt plants and trees, there are generally certain parts that have a much more ſenſible, and much ſtronger ſcent than the reſt. The odour of a plant, or of a tree, hath its principal reſidence ſometimes in the root, ſometimes in the leaves, at other times in the bark or wood, and very frequently in the flowers and ſeeds. Therefore, when you deſign to extract the principle of odour from a vegetable that is not equally odoriferous in every part, you muſt chuſe thoſe parts that have the moſt perceptible and ſtrongeſt ſcent.

PROCESS II.

To extract the Fat Oils of Plants by Decoction in boiling Water. Cacao Butter.

POUND or bruiſe in a marble mortar your vegetable ſubſtances, abounding with the Fat Oil which you intend to extract by decoction: tie them up in a linen cloth;

put this packet into a pan, with ſeven or eight times as much water, and make the water boil. The Oil will be ſeparated by the ebullition, and float on the ſurface of the water. Skim it off carefully with a ladle, and continue boiling till no more Oil appear.

OBSERVATIONS.

The heat of boiling water is capable of ſeparating the Fat Oils from vegetable matters that contain any: but this is to be effected by actual decoction only, and not by diſtillation; becauſe theſe Oils will not riſe in an alembic with the heat of boiling water. We are therefore neceſſitated to collect them from the ſurface of the water, as above directed. By this means a much greater quantity of Fat Oil may be obtained than by expreſſion alone; becauſe the degree of heat applied greatly facilitates the ſeparation of the Oil. For a convincing proof of this truth, take the remains of any vegetable matters, from which the Oil hath been ſo thoroughly expreſſed that they would yield no more; boil them in this manner, and you will obtain a great deal more Oil.

The water uſed in this coction generally becomes milky, like an emulſion; becauſe it contains many oily particles, that are diſperſed in it juſt as in an emulſion. Nevertheleſs, this way of obtaining the Fat Oils is not generally practiſed; becauſe the heat, to which they are expoſed in the operation, occaſions their being leſs mild than they naturally are: but it is an excellent method, and indeed the only one that can be employed, for extracting from particular vegetables certain concrete oily matters, in the form of Butter or Wax; which matters are no other than Fat Oils in a fixed ſtate. The Cacao yields, by this means, a very mild butter; and in the ſame manner is a Wax obtained from a certain ſhrub in America.

The heat of boiling water melts theſe oily matters, which then aſcend to the ſurface of the liquor, and float on it like other Oils. They afterwards fix as they cool, and reſume their natural conſiſtence. We ſhall ſee in the ſequel, that they cannot be extracted in a concrete form by diſtillation, which requires a greater degree of heat than that of boiling water; becauſe diſtillation changes their nature, partly decompoſes them, and prevents their returning to their proper conſiſtence as they cool.

PROCESS III.

To extract Eſſential Oils of Plants by Diſtillation with the Heat of boiling Water. Diſtilled Waters.

PUT into a cucurbit the plant from which you deſign to extract the Eſſential Oil. Add as much water as will fill two thirds of your veſſel, and diſſolve therein half an ounce of Sea-ſalt for every quart of water you uſe. To this body fit on an alembic-head, and to the noſe thereof lute a receiver, with ſized paper, or wet bladder. Set it in a furnace, and let the whole digeſt together, in a very gentle warmth, for twenty-four hours.

This being done, light a wood-fire under your veſſel, briſk enough to make the water in it boil immediately. Then ſlacken your fire, and leave it juſt ſtrong enough to keep the water ſimmering. There will come over into the receiver a liquor of a whitiſh colour, ſomewhat milky; on the ſurface of which, or at the bottom, will be found an Oil; which is the Eſſential Oil of the vegetable you put into the cucurbit. Continue your diſtillation with the ſame degree of heat, till you perceive the liquor come off clear, and unaccompanied with any Oil.

When the diſtillation is finiſhed, unlute the receiver; and, if the Eſſential Oil be of that ſort that it is lighter than water, fill the veſſel up to the top with water. On this occaſion a long-necked matraſs ſhould be uſed for a receiver; that the Oil which floats on the water may collect together in its neck, and riſe up to its mouth. Then in the neck of this veſſel put the end of a thread of cotton-twine, ſo that the depending part without the veſſel may be longer than that in the Oil, and the extremity thereof hang within the mouth of a little phial, juſt big enough to contain your quantity of Oil. The Oil will riſe along the yarn as in a ſiphon, filter through it, and fall drop by drop into the little phial. When all the Oil is thus come over, ſtop your little bottle very cloſe, with a cork coated over with a mixture of wax and a little pitch.

If your Oil be ponderous, and of the ſort that ſinks in water, pour the whole contents of the receiver into a glaſs funnel, the pipe of which muſt terminate in a very ſmall aperture that may be ſtopped with your fore-finger. All the Oil will be collected in the lower part of the funnel: then remove your finger, and let the Oil run out into a little bottle through another ſmall funnel. When you ſee the water ready to come, ſtop the pipe of the funnel, and cork the bottle containing your Oil.

OBSERVATIONS.

ESSENTIAL Oils, though they all reſemble each other in their principal properties, are nevertheleſs very different in ſome reſpects: for which reaſon almoſt every one of them requires a particular management, for obtaining it with the greateſt advantage poſſible, both as to quality and quantity.

One of the firſt things requiſite is, to chuſe the proper time for diſtilling the plant, from which you deſire to extract the Eſſential Oil; becauſe the quantity of Oil varies conſiderably, according to the ſeaſon of the year, as well as the age of the plant. For example, the moſt favourable time for obtaining theſe Oils from the leaves of ever-green plants or trees, ſuch as Thyme, Sage, Roſemary, the Orange, the Bay, the Fir, &c. is the end of Autumn; becauſe theſe vegetables contain a great deal more Oil at that ſeaſon than at any other. With regard to annual plants, they muſt be choſen when in their prime, and juſt before they begin to decline. The time therefore of gathering them is when they begin to flower: and if you want to extract the Oil from the flowers themſelves, you muſt pull them juſt when they are newly blown.

Secondly, it muſt be obſerved, that the Eſſential Oils of plants are, as it were, the chief reſidence and reſervoir of their odorous principle; that they are to be found wherever that principle exiſts, and never where it is not: ſo that what we ſaid concerning the *Spiritus Rector* of plants is applicable here. It muſt be remembered, that all the parts of ſome vegetables are odoriferous. Such plants may be put into the alembic all together, and the Eſſential Oil diſtilled from all their parts at once. But others, and indeed the greateſt number, have no odour, or at leaſt none that is very perceptible, except in ſome particular parts; as in their leaves, flowers, roots, or ſeeds; therefore, when you want to have the Eſſential Oil of ſuch a plant, you muſt chuſe that part in which the Odour reſides. The ſenſe of ſmelling muſt be the artiſt's principal guide on this occaſion.

Thirdly, all vegetables, and all the parts of vegetables, have not the ſame texture: ſome are hard and compact, as woods, barks, and ſome roots; others are tender and ſucculent, as moſt annual plants, and ſome fruits. For this reaſon,

ſon, they muſt be differently prepared for diſtillation. It may be laid down as a general rule, that the cloſer and more compact their texture is, the more they require to be opened and divided, either by comminuting them into ſmall particles, or by digeſting them a conſiderable time in water acuated with Salt.

Fourthly, though all Eſſential Oils be capable of riſing in diſtillation with the heat of boiling water, yet they have not all an equal degree of levity and weight: on the contrary, they vary exceedingly in this reſpect: ſome, as, for inſtance, thoſe of all our European aromatics, being lighter than water, ſo that they always float on its ſurface; whereas others, ſuch as thoſe of Cloves, Saſſafras, &c. which are Indian aromatics, are heavier than water, and always ſink in it by their ſpecific gravity. Theſe differences therefore require different methods of diſtillation. It is proper, for example, to make uſe of a low alembic in diſtilling ſuch Eſſential Oils as are heavier than water; and, moreover, to facilitate their ſeparation, by applying a degree of heat ſomewhat ſtronger than that of boiling water. This is eaſily done by impregnating the water with a proper quantity of Sea-ſalt, or the Vitriolic Acid; for, the more ſaline matters are contained in water, the more will the degree of heat it acquires, by being brought to boil, exceed that of pure boiling water.

Fifthly, Eſſential Oils differ from one another in point of fluidity. Some are as thin and as fluid as Spirit of Wine: of this number is the Eſſential Oil of Turpentine. Others, again, are thick, and even congeal as they cool: ſuch, for inſtance, is the Oil of Roſes. In diſtilling Oils of this latter ſort, care muſt be taken that the ſpout of the alembic head do not grow too cold, but be kept always in ſuch a degree of warmth as may prevent the Oil from fixing in it, and ſtopping it up; which would interrupt the diſtillation, and might alſo occaſion ſome other more conſiderable inconveniencies, of which we ſhall take notice preſently.

From what hath been ſaid it appears, that the diſtillation of Eſſential Oils cannot be regulated by any one general rule; but that the manner of operating muſt be a little varied, according to the nature of the Oil to be diſtilled, and to that of the vegetable from which it is to be drawn.

The time of day fitteſt to gather plants for this diſtillation is the morning before ſun-riſe; becauſe the coolneſs of the night hath ſhut all their pores, and concentrated their odour: whereas in the evening, after the plants have been expoſed all day to the heat of the ſun, their odorous principle is in a great meaſure diſſipated, and they are left almoſt quite exhauſted of it. Now, the more of the odorous principle the plants contain, the more Eſſential Oil will they yield, and the more virtue will that Oil have.

Plants freſh gathered, and as yet full of moiſture, do not yield ſo much Oil in diſtillation as they do when dried; becauſe the oily particles in a very moiſt plant are more diffuſed, and even ſeparated from each other, by the interpoſition of the aqueous parts; whence it comes to paſs that, in diſtillation, they aſcend in a ſtate of ſeparation from each other; ſo that being diſperſed through the water they give it a milky colour, like that of an emulſion; and cannot unite together but in ſmall quantities, which hinders their being eaſily ſeparated from the water.

This inconvenience doth not happen, or at leaſt is conſiderably leſs, when the greateſt part of the humidity of the plant is evaporated by deſiccation: for the oily particles, being thus delivered from the intervening aqueous parts, which kept them ſeparated from each other, are brought nearer together, unite, and form little viſible globules of Oil, which eaſily emerge from the water employed in the diſtillation. But, in drying plants from which the Eſſential Oil is to be extracted, great care muſt be taken that they be neither expoſed to the ſun, nor laid in a warm place; becauſe the heat would carry off part of their odour, and even, from ſome plants, a pretty conſiderable quantity of their Eſſential Oil.

Plants of a looſe texture, that eaſily give out their Eſſential Oils, need not be comminuted, or macerated in water with Salt. But this method muſt unavoidably be taken with ſuch as are hard, and do not readily part with their Oil. Woods, barks, roots, for inſtance, muſt be firſt raſped, then ſet to macerate in water impregnated with Salt, as before directed; and this ſometimes for ſeveral weeks before they be diſtilled.

On this occaſion Salt procures three different advantages. In the firſt place, it prevents the matters, that muſt ſtand in maceration for ſome time, from running into fermentation: an inconvenience that would conſiderably diminiſh the quantity of Eſſential Oil, or perhaps rob us of the whole, by converting it into an Ardent Spirit, if the fermentation were ſpirituous; or into a Volatile Alkali, if it went on to the laſt ſtage, and as far as putrefaction. In the next place, it acuates the water, and renders it more capable of penetrating and properly dividing, during the maceration, the texture of the plant which requires to be thus prepared.

Laſtly, it adds a little to the heat of the boiling water, and ſo promotes the aſcent of the heavieſt Oils.

Nevertheleſs, when you find it neceſſary, for the reaſons aſſigned above, to mix Salt with the water to be employed in diſtilling your Eſſential Oil, you muſt be cautious of putting in too much. You will indeed obtain, by means thereof, much more Oil than if you diſtilled it without Salt: but, as a great quantity of Salt will make the water acquire a much greater degree of heat than that of pure boiling water, a good deal of the heavy Oil of the vegetable will be raiſed by ſuch a heat, mix with the Eſſential Oil, deprave it, and make it like thoſe that are adulterated with a mixture of ſome heterogeneous Oil, as will be afterwards ſhewn.

When every thing is prepared for diſtillation, it is proper, as directed in the proceſs, to apply at once a flaming fire, briſk enough to make the liquor boil immediately: for, if the water be kept long heating before it be made to boil, the Eſſential Oil, which cannot riſe without the heat of boiling water, will, by a leſs degree of heat, be only agitated, daſhed about every way, and churned as it were; by which means it will be divided into very minute particles, and diſperſed in the water, which will thence acquire a milky colour: and conſequently we ſhall fall into the inconvenience that was pointed out above, as happening when we diſtil plants without having dried them, and while they are loaded with all the moiſture and ſap that was in them when freſh gathered.

When the water in the cucurbit boils, it will be known by the noiſe that boiling water uſually makes, which is produced by the numerous bubbles that riſe and burſt on its ſurface. The ſpout of the alembic is then ſo hot, that a man cannot lay his finger on it, without ſuch a ſenſation of burning heat as is not to be endured. With this degree of heat the water diſtils in drops, which ſucceed each other ſo faſt, that they ſeem to form a continued ſmall ſtream; and this water is replete with much Eſſential Oil.

And now it is proper to weaken the fire conſiderably, ſo as to leave it but juſt ſtrong enough to keep the liquor gently boiling: for if the diſtillation be urged too precipitately, the aqueous and oily vapours, being forcibly hurried up by too great a heat, may carry along with them ſome parts of the plant, which may ſtick in the ſpout, ſtop it up, and endanger the burſting of the veſſel, or at leaſt the forcing off its head, by the exceedingly rarefied particles of water, oil, and air, all ſtriving to eſcape at the ſame time; and theſe burning

ing hot vapours, being diſcharged with impetuoſity, may not only ſcald the operator, but injure his lungs.

In ſuch diſtillations it is of conſequence to keep conſtantly cooling the head of the alembic, by frequently renewing the water in the refrigeratory, in order to facilitate the condenſation of the oily particles. The water in the cooler ought to be renewed when it begins to ſmoke very perceptibly.

Whatever care be taken to ſave as much of the Oil as poſſible, and to prevent its being left diſperſed in the water, yet ſome loſs of this kind cannot be totally avoided: and thus the water that riſes in diſtilling the Oil is always more or leſs milky, and ſtrongly ſcented, even after it is ſeparated from the Eſſential Oil. Yet this portion of the Oil and of the odorous principle, which is retained by the water employed in ſuch diſtillation, is not therefore loſt: the water impregnated with theſe principles partakes of the properties of the plant from which the Eſſential Oil was drawn, and may be uſed medicinally: it is known in Pharmacy by the title of the *Diſtilled Water* of the plant.

The ſame water may be uſed again, with advantage, in diſtilling the Eſſential Oil of a freſh plant of the ſame ſort; becauſe the oily and odorous particles, with which it is impregnated, joining with thoſe afforded by the freſh plant, form larger *moleculæ*, capable of uniting more eaſily, and emerging better from the water; and conſequently they increaſe the quantity of Oil. Thus the ſame water may be always employed in new diſtillations; and, the oftener it is uſed, with the greater advantage may it be uſed again.

After all the Eſſential Oil is riſen, if the diſtillation be continued, and the receiver changed, the liquor that will then come off will not be milky, but limpid. It will have no odour at all of the plant, but a kind of ſouriſh ſmell; and indeed it is a part of the Acid of the vegetable in the ſtill, which is elevated by the heat of boiling water, after all the Eſſential Oil is come over.

If you intend to keep the diſtilled water which hath ſerved as a vehicle to the Eſſential Oil, and deſign it for medicinal uſe, great care muſt be taken to ſtop the diſtillation before this acid phlegm begin to riſe: for, if it ſhould mix with the diſtilled water, it would ſpoil it, and hinder it from keeping; probably becauſe it contains ſome mucilaginous parts, which are apt to putrify.

PROCESS IV.

To extract the Eſſential Oils of Plants by Diſtillation per Deſcenſum.

REDUCE to a powder, or a paſte, the vegetable ſubſtances from which you intend to extract the Eſſential Oil by the method propoſed. Lay this matter about half an inch thick on a fine, cloſe, linen cloth. If it be dry and hard, expoſe the cloth containing it to the ſteam of boiling water, till the matter become moiſt and ſoft. Then lay the cloth, with its contents, over the mouth of a very tall cylindrical glaſs veſſel, which is to do the office of a receiver in this diſtillation; and, by means of a piece of ſmall pack-thread, faſten down the extremities of the cloth, by winding the thread ſeveral times over them and round the veſſel; in ſuch a manner, however, that the cloth be not tight, but may yield to a ſmall weight, and ſink about five or ſix lines deep into the veſſel over which it is faſtened. Set this recipient in a larger veſſel, containing ſo much cold water as will reach half way up the cylindrical veſſel; which, having little in it but air, muſt be ballaſted with as much lead as will ſink it to the bottom of the water.

On the cloth containing the ſubſtance to be diſtilled ſet a flat pan of iron or copper, about five or ſix lines deep, that may juſt fit the mouth of the glaſs veſſel over which the cloth is faſtened, ſo as to ſhut it quite cloſe. Fill this pan with hot aſhes, and on theſe lay ſome live coals. Soon after this, you will ſee vapours deſcend from the cloth, which will fill the recipient, and drops of liquor will be formed on the under ſide of the cloth, from whence they will fall into the veſſel. Keep up an equal gentle heat till you perceive nothing more diſcharged. Then uncover the recipient: you will find in it two diſtinct liquors; one of which is the phlegm, and the other the Eſſential Oil of the ſubſtance diſtilled.

OBSERVATIONS.

THE apparatus for diſtilling above deſcribed is very convenient, when we have not the veſſels neceſſary for diſtilling with water, or when we want to obtain the Eſſential Oil of any vegetable ſubſtance in much leſs time. The aqueous and oily parts of the ſubſtances diſtilled in this manner, being

ing rarefied by the heat of the fire placed over them, cannot aſcend upwards, becauſe they are cloſe confined on that ſide; and, moreover, the fire which rarefies them poſſeſſing all the upper part of the veſſel in which they are contained, they are forced to fly from it to the place which moſt favours their condenſation: and this determines them to deſcend in the recipient, where they meet with a coolneſs that condenſes and fixes them. It was with a view to promote this condenſation, that we ordered the lower part of the recipient to be ſunk in cold water.

Cloves are one of thoſe ſubſtances whoſe Eſſential Oil is beſt obtained by this method. In the ſame way alſo may be drawn the Eſſential Oil of Lemon-peel, Citron-peel, Orange-peel, Nutmegs, and ſeveral other vegetable ſubſtances: but you muſt be cautious of applying too ſtrong a heat; for in that caſe the Oil, inſtead of being white and limpid, acquires a red, dark-brown, blackiſh colour, is burnt, and ſmells of empyreuma: and, on the other hand, if you do not apply a proper degree of heat, you will ſcarce get any Oil at all. It is the ſureſt, and therefore the beſt, way to diſtil theſe Oils with water in an alembic. And indeed the diſtillation *per deſcenſum* is ſeldom uſed, but out of curioſity to try its effect, or on ſuch preſſing occaſions as allow no choice.

PROCESS V.

Infuſions, Decoctions, and Extracts of Plants.

MAKE ſome water boiling-hot, and then take it off the fire. When it ceaſes to boil, pour it on the plant of which you deſire to have the Infuſion; taking care there be enough of it to cover the plant entirely. Cover the veſſel, and let your plant lie in the hot water for the ſpace of half an hour, or longer, if it be of a firm cloſe texture. Then pour off the water by inclination: it will have partly acquired the colour, the ſmell, the taſte, and the virtues of the plant. This liquor is called an *Infuſion*.

To make the Decoction of a vegetable ſubſtance, put it into an earthen pan, or into a tinned copper veſſel, with a quantity of water ſufficient to bear being boiled for ſeveral hours, without leaving any part of the plant dry. Boil your plant more or leſs according to its nature; and then pour off the water by inclination. This water is impregnated with ſeveral of the principles of the plant, of which we ſhall take notice in the following obſervations.

OBSERVATIONS.

WATER, eſpecially when boiling hot, is capable of diſſolving not only all that is purely ſaline in vegetables, but alſo a pretty conſiderable quantity of their Oil and of their earth, which, by contracting an union with the ſaline parts, have formed ſaponaceous, gummy, and mucilaginous compounds, that are ſoluble in water. After violent and long-continued boiling, therefore, there remains nothing in the plant but the pureſt oily part, and ſuch as is the moſt fixed, that is, the moſt cloſely united with the earth of the plant. I ſay, the moſt fixed: for ſome part of the oily matters, though not ſoluble in water, may be ſeparated by the action of boiling water, when thoſe matters abound greatly in the vegetable decocted; as we have ſeen happen to the Fat Oils of certain vegetable matters; but in that caſe theſe oily matters float upon the Decoction, and do not conſtitute a part of it.

From what we have already ſaid, touching the analyſis of plants, it ſeems evident, that, if thoſe decocted be odoriferous and contain an Eſſential Oil, the Decoction will contain none, or at moſt but very little, of their Eſſential Oil, or their odorous principle; ſeeing we know that theſe ſubſtances cannot bear the heat of boiling water, without being carried off and entirely diſſipated by it. Therefore, when we make a decoction of an aromatic plant, containing an Eſſential Oil, we may be aſſured that it will not poſſeſs the virtues, either of the odorous part, or of the Eſſential Oil, and that it will have none but thoſe of the other more fixed principles of the plant, with which it may be impregnated. The Decoction of ſuch a plant perfectly reſembles the water left in the cucurbit, after diſtilling its Eſſential Oil. But for thoſe plants in which there are no ſuch volatile parts, or whoſe virtue doth not reſide in thoſe principles, ſuch as aſtringent and emollient plants, for example, that owe their properties wholly to an earthy Salt, or to a mucilage, they are capable of communicating their whole virtue to the water in which they are infuſed or decocted.

If, on one hand, the Salts of plants render ſome portion of the principles of thoſe plants ſoluble in water, ſuch as part of their Oil and their earth, which if they were pure would not diſſolve therein; on the other hand, theſe principles, being of their own nature indiſſoluble in water, hinder the Salts, by the union they have contracted together, from diſſolving in it ſo eaſily, ſo ſoon, and in ſuch quantities, as if they were pure. This is ſo true, that water, though boiled long and violently, is far from extracting out of plants all thoſe parts that it is capable of diſſolving. If, after boiling a plant in water, as directed in the proceſs, this water be poured off, freſh water added, and a ſecond decoction made in the ſame manner as the firſt, the water of this latter decoction will, by that means, be almoſt as ſtrongly impregnated with the principles of the plant as the former was. Mr. Boerhaave was obliged to make twenty ſucceſſive decoctions of the ſame plant, to wit, Roſemary, before the water came off the plant colourleſs and inſipid; in a word, juſt as it was before the plant was boiled in it.

Mr. Boerhaave obſerves, that a plant, after having thus given out all that water can diſſolve, ſtill retains exactly the ſame form that it had before it underwent any of the many boilings neceſſary to exhauſt it; that its colour, from being green at firſt, becomes brown; and that the plant, which when green is lighter than water, or at leaſt doth not ſink in it, is heavier after this operation, and falls to the bottom. This is a proof that the water hath extracted out of the plant its lighteſt ſubſtances, aſſuming their places itſelf, and that it hath left nothing but its heavieſt principles, namely, its fixed oil and its earth. We ſhall afterwards examine more particularly theſe remains of plants exhauſted by water.

If the Infuſions and Decoctions of plants be filtered, and evaporated in a gentle heat, they become Extracts, that may be kept for whole years, eſpecially if they be evaporated to a thick conſiſtence; and better ſtill if they be evaporated to dryneſs.

From what hath been ſaid concerning the Infuſions, Decoctions, and Extracts of plants, it follows, 1. That Infuſions and Decoctions of aromatic plants do not furniſh a complete Extract of thoſe plants; becauſe they do not contain the volatile and odorous parts, in which the principal virtue of ſuch plants uſually reſides. If therefore you deſire to make Extracts of ſuch vegetables, that ſhall have no defect, you muſt employ their juices drawn by expreſſion, or water impregnated with their principles by the means of trituration, and evaporate the liquor by ſpreading it over a great number of plates, in order to enlarge its ſurface, and quicken en the evaporation, which muſt be effected by the heat of the ſun alone, or the well-tempered warmth of a ſtove.

2. It may alſo be inferred, that water alone, aided by the degree of heat it is capable of acquiring by being made to boil, is not ſufficient to effect the complete analyſis of a plant; ſince not only ſome of its principles are ſtill left combined in it, though exhauſted as much as it can be by boiling water; but alſo ſeveral of the ſubſtances extracted from it by water are compounds of ſome of the principles of the plant, and ſuſceptible of a much more accurate analyſis; as we ſhall be convinced when we come to examine the effects which a degree of heat ſuperior to that of boiling water is able to produce on entire plants, on their Extracts, and on their remains exhauſted as much as they can be by boiling water.

But before we enter on that part of the analyſis, it is proper to conſider the experiments and combinations that may be made with the principles we have already obtained; in order to diſcover their nature, and in ſome meaſure analyze even them. Eſſential Oils in particular deſerve to be thus examined.

We alſo obtain from certain plants, with a degree of heat leſs than that of boiling water, a Volatile Alkali, which exiſts formally in them: but as theſe plants, when analyzed, yield principles different from thoſe we obtain out of all other vegetable ſubſtances, and as they reſemble animal matters, we ſhall refer their analyſis to a diſtinct chapter.

CHAP. V.

Of OPERATIONS *on* ESSENTIAL OILS.

PROCESS I.

The Rectification of Eſſential Oils.

PUT into a cucurbit the Eſſential Oil you propoſe to rectify. Set the cucurbit in a *balneum mariæ;* fit to it a head of tin, or of copper tinned, together with its refrigeratory; and lute on a receiver. Make the water in the bath boil, and keep up this degree of heat till nothing more will come over. When the diſtillation is finiſhed, you will find in the receiver a rectified Eſſential Oil, which will be clearer, thinner, and better ſcented, than before it was thus re-diſtilled; and in the bottom of the cucurbit will be left a matter of a deeper colour, more tenacious, more reſinous, and of a leſs grateful ſmell.

OBSERVATIONS.

Essential Oils, even the pureſt, the beſt prepared, and the thinneſt, ſuffer great changes, and are much impaired by growing old: they gradually turn thick and reſinous; their ſweet grateful ſcent is loſt, and ſucceeded by a more diſagreeable ſmell, ſomewhat like that of Turpentine. The cauſe of theſe changes is, that their fineſt and moſt volatile part, that which contains moſt of the odorous principle, is diſſipated and ſeparated from that which contains leaſt of it; which therefore grows thicker, and comes ſo much the nearer to the nature of a reſin, as the quantity of Acid, that was diſtributed through the whole Oil before the diſſipation of the more volatile part is, after ſuch diſſipation, united and concentrated in the heavieſt part; the Acid in Oils being much leſs volatile than the odorous part, to which alone they owe their levity.

Hence it appears what precautions are to be uſed for preſerving Eſſential Oils, as long as poſſible, without ſpoiling. They muſt be kept in a bottle perfectly well ſtopped, and always in a cool place, becauſe heat quickly diſſipates the volatile parts. Some authors direct the bottle to be kept under water.

If theſe Oils ſhould grow thick and reſinous by age, yet they are not to be thrown away. We ſhall ſhew, in the analyſis of Balſams and Reſins, that, from theſe thick and even ſolid ſubſtances, Eſſential Oils may be drawn, as thin and as limpid as from plants. Eſſential Oils, thickened by time, may therefore be treated like Balſams, and actually analyzed, by ſeparating all the ſubtile odorous matter they contain from their thick acid parts. For this purpoſe they need only be diſtilled with a degree of heat juſt ſufficient to elevate the thin odorous parts, without raiſing the thick matter.

The reſidue left at the bottom of the veſſel, becauſe it could not riſe in diſtillation, is much thicker and leſs odorous than the Oil was before rectification. The reaſon of this is evident, and follows from what hath juſt been ſaid. This remainder diſſolves in Spirit of Wine more readily, and in greater quantity, than the light Oil drawn from it; becauſe it contains more Acid, and becauſe Oils owe their ſolubility in this menſtruum to their Acid part, as is proved in our Memoir on Oils already quoted.

When we come to treat of Reſins, we ſhall inquire more particularly what this remainder is, and what principles it yields when analyzed: in this place it is ſufficient to take notice, that though all the Oil of which it made a part came over at firſt with the heat of boiling water, yet it cannot now be raiſed by the ſame degree of heat in diſtillation; becauſe it is not now combined with the principle of odour which gives the Oil its volatility, and becauſe it is rendered ſluggiſh by being clogged with too great a proportion of Acid.

From what hath been already ſaid, it muſt be concluded, that Eſſential Oils ſuffer great diminution by being rectified; and that in proportion to the quantity of reſinous matter left behind. All this reſinous matter, while combined with a proper quantity of the odorous principle of the plant, (that is, at the time of its being diſtilled, and a little while after), was really an Eſſential Oil: the change of its nature, therefore, is entirely owing to its having loſt that principle.

An Eſſential Oil, though rectified, is ſtill as apt to change and be ſpoiled as before, becauſe it ſtill continues to loſe its odorous principle by degrees. After ſome time, therefore, it requires a ſecond rectification, which again leſſens its quantity. In ſhort, it is plain that Oils will, in a number of years, greater or ſmaller according to their nature, and the manner in which they are kept, be wholly changed, and metamorphoſed into a reſinous matter, from which no thin Oil can be drawn with the heat of boiling water: and this is a proof of the fugacity of that odorous principle, or *Spiritus Rector*, of plants, which, when united with their lighteſt Oil, gives it the character of an Eſſential Oil.

This reſinous matter, to which Eſſential Oils are finally reduced, being ſubjected to repeated diſtillations, with a degree of heat ſuperior to that of boiling water, is ſtill capable of yielding a certain portion of a thin, limpid, ſweet-ſcented Oil, which is as light as an Eſſential Oil; as we obſerved before is the caſe with Fat Oils drawn by expreſſion: but the thin Oil obtained by this means, though it poſſeſſes almoſt all the properties of an Eſſential Oil, is not for all that a genuine one; ſeeing it hath not the ſame odour with the plant from which it was originally drawn.

Eſſential Oils muſt be rectified in the *balneum mariæ*, as ordered in the proceſs: for, as ſome of the Oil touches the ſides of the veſſel in the operation, if that veſſel be made hotter than boiling water, the thick matter will riſe with the thin Oil, which therefore will not be rectified.

Rectification is of uſe not only for procuring to Eſſential Oils the tenuity and levity they may have loſt by age, but alſo to ſeparate them from other oily matters with which they may be adulterated. If, for inſtance, an Eſſential Oil be not properly diſtilled; if, by the addition of too much Salt, the water have acquired a degree of heat greater than that of pure boiling water, and if, in conſequence thereof, ſome of the heavy Oil of the plant have riſen with the Eſſential Oil, and mixed therewith, the Eſſential Oil may, by rectification, be ſeparated from this heterogeneous Oil; which, being heavier and incapable of riſing with the heat of pure boiling water, will remain at the bottom of the veſſel.

The effect will be the ſame, if your Eſſential Oil be falſified with a mixture of any Fat Oil, as is often the caſe: for, ſome of them being extremely dear, the vender frequently adds a portion of Fat Oil to increaſe the quantity. For this purpoſe Oil of Ben is generally uſed.

When an Eſſential Oil is thus falſified with a mixture of any Fat Oil, it may be diſcovered by letting a few drops of it fall into rectified Spirit of Wine; which will diſſolve the Eſſential Oil only, leaving the Fat Oil quite untouched.

Eſſential Oils are ſometimes falſified by mixing them with a certain quantity of Spirit of Wine. This fraud doth not render their ſmell leſs fragrant: on the contrary, it becomes rather more agreeable and quicker. In order to try an Oil ſuſpected of being falſified in this manner, drop a little of it into very clear water. If a milky cloud appear in the water, be aſſured the Oil is mixed with Spirit of Wine: for as this liquor unites more readily with water than with Oil, it quits the Oil with which it was mixed to incorporate with the water: mean time a good deal of the Oil that was diſſolved by the Spirit of Wine, and is now ſeparated from it by the intervention of water, neceſſarily remains diſperſed through this water in very ſmall particles; and theſe form the milky cloud produced on this occaſion.

An Eſſential Oil may alſo be adultered with another Eſſential Oil that is much more common, and of much leſs value. Thoſe who practiſe this fraud generally employ Oil of Turpentine for that purpoſe, on account of its cheapneſs and tenuity. The cheat is eaſily diſcovered, by moiſtening a linen rag with the Oil ſuppoſed to be thus falſified, and then holding the rag a little before the fire, which preſently diſſipates the odorous part of the falſified Oil. This odour, which prevented our diſtinguiſhing that of the Oil of Turpentine, being vaniſhed, the peculiar ſmell of the Turpentine, which is much more permanent, remains alone; and is ſo perceptible that it cannot eaſily be miſtaken.

Thoſe who are much accuſtomed to ſee and examine Eſſential Oils, have ſeldom occaſion to make the experiments here propoſed for diſcovering their qualities. A certain degree of thickneſs, partaking of unctuoſity, in an Eſſential Oil, convinces them that it is falſified with a Fat Oil: on the other hand, a greater degree of tenuity, together with a quicker ſmell, than a pure Eſſential Oil ought to have, diſcovers the admixture of Spirit of Wine. Laſtly, any one, whoſe ſenſe of ſmelling is not very dull, will eaſily diſcover the odour of the Oil of Turpentine, though diſguiſed by that of the Eſſential Oil with which it is mixed.

PROCESS II.

To fire Oils by combining them with highly concentrated Acids: inſtanced in Oil of Turpentine.

MIX together, in a glaſs, equal parts of concentrated Oil of Vitriol, and highly ſmoking freſh-drawn Spirit of Nitre: pour this mixture at ſeveral times, but ſuddenly, on three parts of Oil of Turpentine, ſet for that purpoſe in a glaſs baſon. By a part here muſt be underſtood a dram at leaſt. A moſt violent commotion, accompanied with ſmoke, will immediately be raiſed in the liquors, and the whole will take fire in an inſtant, flame, and be conſumed.

OBSERVATIONS.

THERE is not in Chymiſtry a phenomenon more extraordinary, and more ſurpriſing, than the firing of Oils by mixing them with Acids. It could never have been ſuſpected that a mixture of two cold liquors would produce a ſudden, violent, bright, and laſting flame, like that we are at preſent conſidering. Beccher gave notice, in his *Phyſica ſubterranea*, that highly rectified Spirit of Wine would be ſet on fire by mixing it with highly concentrated Oil of Vitriol.

Afterwards Borrichius, a Daniſh Chymiſt, publiſhed a proceſs for kindling Oil of Turpentine, by mixing it with the Nitrous Acid, as we find in the Philoſophical Tranſactions of Copenhagen for the year 1671. Moſt Chymiſts have ſince tried to repeat thoſe experiments, and particularly to fire the Oil of Turpentine by mixing it with Oil of Vitriol, or Spirit of Nitre; but to no purpoſe, when they made uſe of the Oil of Vitriol, till Mr. Homberg told us, in the Memoirs of the Academy of Sciences for 1701, that he had fired Oil of Turpentine by mixing it with Oil of Vitriol.

To make the experiment ſucceed he requires, "That the "Oil of Vitriol be dephlegmated as much as poſſible, and "that the Oil of Turpentine be the laſt that comes over in "diſtillation, which is thick like a ſyrop, and of a dark-"brown colour; for that which is white, and riſes at the "beginning of the diſtillation, never takes fire." Theſe are his own words: but no body elſe hath ever ſucceeded in making the experiment.

Tournefort had ſucceeded, a little before Homberg, in firing, not Oil of Turpentine indeed, in which he always failed, but the Oil of Saſſafras, by mixing it with an equal quantity of well dephlegmated Spirit of Nitre. Homberg came afterwards, as appears by the Memoirs of the Academy for the year 1702, to fire with Spirit of Nitre the Eſſential Oils of the aromatic plants of India; and in 1706 Mr. Rouviere fired, with Spirit of Nitre, the empyreumatic Oil of Guaiacum. While this Oil of Guaiacum is burning, a porous ſpongy body riſes from the midſt of the flame, to the height of about two feet above the veſſel.

Laſtly, ſeveral years after all theſe diſcoveries, Meſſrs. Geoffroy and Hoffman, the one at Paris, and the other at Hall in Saxony, found a way to fire the Æthereal Oil of Turpentine, each by a different proceſs; yet agreeing in this, that they both combined the Vitriolic Acid with the Nitrous, and with this compound Acid fired that Æthereal Eſſential Oil, which is one of the thinneſt, and, probably for that very reaſon, the moſt unfit to produce a flame with Acids.

The moſt celebrated Chymiſts, as appears from this ſhort account, have employed themſelves in firing Eſſential Oils; but no body attempted the experiment on Fat Oils. It was not ſo much as ſuſpected that they were capable of taking fire after this manner, till in 1745 I read before the Academy a Memoir on Oils, which I have already mentioned, and in which I expreſs myſelf thus:

"I put two ounces and a half of Walnut Oil into the "bottom part of a broken retort, having the figure of a cap, "or concave hemiſphere; and poured thereon two ounces of "ſmoking Spirit of Nitre. It was ſcarce put in when a "conſiderable ebullition aroſe, with a very thick ſmoke. As

" I found it continually increaſing, and very faſt too, I re-
" tired a little, that I might obſerve the event without dan-
" ger. This caution was not unneceſſary: for immediately
" the whole mixture blew up as high as the cieling, with a
" noiſe like the diſcharge of a muſket. Nothing was left in
" the veſſel but a black matter, which ſtill continued to boil
" a little and run over, and at laſt remained very rare,
" ſpungy, and as full of holes as a honeycomb: its conſiſt-
" ence alſo was ſuch that it did not ſtick to my fingers
" when I handled it.

" As Mr. Geoffroy, who firſt found the means of firing
" the natural Balſams, obſerved in them a ſimilar exploſion
" on that occaſion, it appears that my Oil was very near
" taking fire in this experiment: which makes me preſume
" that we may at laſt ſucceed in firing Fat Oils likewiſe, and
" conſequently all others; ſeeing theſe have always been
" looked upon as the moſt unlikely to produce that pheno-
" menon. I imagine that, to accompliſh this, nothing more
" is neceſſary than to make uſe of ſufficiently great quanti-
" ties, and to order it ſo that the ſurfaces of the liquors,
" where they come into contact, may be of a large extent."

Afterwards, in 1747, Mr. Rouelle read before the Academy a Memoir on the accenſion of Oils by Acids. That Memoir contains a great number of curious experiments, and peculiar manual operations deſcribed very diſtinctly, from which there reſults a general method of firing without fail, not only Eſſential Oils, but even any Fat Oil whatever: ſo that my conjecture, concerning the poſſibility of firing theſe latter Oils, mentioned in my above-cited Memoir of 1745, is now changed into a certainty. I ſhall proceed to explain how I conceive theſe accenſions are brought about, and endeavour to account for the phenomenon from ſuch cauſes as to me ſeem the moſt probable.

A due attention to the phenomena produced by mixing Oils with Acids will enable us, I imagine, to diſcover the natural cauſe why the Oils take fire. It is certain, and demonſtrated by the moſt deciſive experiments, that the friction of ſeveral bodies rubbing againſt each other produces heat; and that when theſe bodies are combuſtible, and the heat produced by their friction riſes to a certain degree, they take fire. This, in my opinion, is what happens to Oils when mixed with concentrated Acids. When theſe two ſorts of ſubſtances ruſh into union with rapidity, as in the experiments under conſideration, there muſt neceſſarily be a great friction among their parts. This friction produces the heat obſerved at the time of their union. The more concentrated the Acids are, with the greater violence and rapidity do they act upon the Oils, and the greater is the heat raiſed. If the Acids be concentrated to ſuch a degree as to produce, by uniting with the Oils, a heat equal to that of an ignited body, the combuſtible ſubſtances that are expoſed to it, which in this caſe are Oils, muſt needs take fire and flame.

The heat produced on this occaſion is ſo great, that, even when the inflammation doth not take place, if you touch the ſurface of the Oil with your finger, as ſoon as the Acid hath had its effect, you will find it burn you like a live coal.

Two pieces of wood, rapidly and violently rubbed againſt each other, take fire. What is it that is kindled in this caſe? It can be nothing but their Oil: for they contain no other combuſtible principle. Why doth this Oil take fire? I do not think it poſſible to aſſign any reaſon for it, but the heat produced by the friction of the pieces of wood containing the Oil. If, when Oil is diſperſed in a body, of which it is only one component principle, and conſequently mixed with many ſaline, aqueous, and earthy parts, that are not inflammable, but, on the contrary, make the Oil leſs ſo, the Oil nevertheleſs takes fire, and burns when agitated by a ſufficient degree of heat; why ſhall not this very Oil, when ſeparated from the mixt of which it made a part, when united into one diſtinct maſs, and entirely, or almoſt entirely, freed from the heterogeneous, incombuſtible parts with which it was combined, and conſequently now more inflammable than before; why, I ſay, ſhall it not take fire, when expoſed to a degree of heat equal, or rather ſuperior, to that which is produced by rubbing two pieces of wood together?

Let us now examine the phenomena produced when Oils are fired by Acids, all the circumſtances that favour or hinder their accenſion, and ſee if they agree with the explanation here offered.

Firſt, no ſort of Oil will take fire with any Acid whatever that is not highly concentrated; for weak Acids act but feebly on Oils, and diſſolve them ſlowly; ſo that the friction is neither quick nor violent, and conſequently produces too faint a heat, far below the degree of ignition.

Secondly, no inflammation is produced when Acids and Oils are mixed in too ſmall quantities; but the more Acid and Oil you mix together, the greater is the certainty of ſucceeding: for the heat is exactly in proportion to the friction that produces it; and the total quantity, or amount, of this friction is ſo much the greater, as there are more particles rubbing againſt each other at the ſame time. So that if a very ſmall quantity of Acid and Oil be mixed together, there will be but a very ſmall quantity of friction, and conſequently a very ſmall quantity of heat; and in that caſe no inflammation. It was with a view to avoid theſe inconveniencies, and to procure the oppoſite advantages in as great a degree as poſſible, that, in the paſſage above quoted from my Memoir of Oils, I propoſed mixing together large doſes of Acid and of Oil, as one of the means by which we might ſucceed in the accenſion of Fat Oils.

Thirdly, the figure of the veſſel, in which the two liquors are mixed together, is not a matter of indifference. A wide-ſpreading veſſel, of a large diameter with reſpect to the quantity of liquor it is to contain, favours the inflammation much more than one of a ſmall diameter. Nay, it may not ſucceed at all in too narrow a veſſel, though all other circumſtances be properly attended to.

The reaſon of this is, that the activity of heat produced by friction is not in proportion to the ſucceſſive, but to the ſimultaneous frictions: for the heat actually produced by the frictions of an hundred particles, rubbing ſucceſſively againſt each other, with intervals ſufficient to let the heat go off, almoſt as faſt as it is generated, would be equal to the friction of a ſingle particle only; whereas the heat actually produced by the friction of the ſame number of particles, all rubbing againſt each other at the ſame inſtant, would be equal to the frictions of all the particles taken together, and conſequently an hundred times more active than the other *. This being laid down, it is eaſy to conceive how a large veſſel favours the accenſion more than a ſmall one. It is certain that two liquors which mutually preſent large ſurfaces to each other, at the inſtant of their being mixed together, touch each other at one and the ſame time in a much greater number of points, than if each had but a ſmall ſurface; and conſequently that they muſt unite much ſooner, and with greater rapidity, in the former caſe than in the latter.

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* I believe this propoſition is not ſtrictly true: for it appears to me, that, in order to make the heat, produced by the ſimultaneous frictions of an hundred particles, an hundred times more active than that produced by the ſucceſſive frictions of the ſame number of particles, it is neceſſary that the ſimultaneous frictions ſhould act all together in one point or center; which is impoſſible. But, as the particles that rub againſt each other, in the preſent caſe, are very near and contiguous, it is ſtill true that the heat, reſulting from their ſimultaneous frictions, is much more active than that produced by ſucceſſive frictions only: which is ſufficient for our preſent purpoſe.

With theſe views, and in order to give the liquors this advantageous diſpoſition, I recommended it as what would greatly promote the inflammation of Fat Oils, to order the liquors ſo, that, at the moment of their mixture, a large ſurface of each might come into contact with the other.

Fourthly, if we reflect on the experiments hitherto made for kindling Oils by Acids, we ſhall eaſily be convinced that all Oils are not equally apt to be fired; and that light, æthereal, very thin, Eſſential Oils do not produce this phenomenon ſo readily and ſo ſurely, as thoſe of the ſame kind that are heavy and thick, or at leaſt ſoon grow thick upon being mixed with Acids.

Mr. Homberg ſays poſitively in the above-cited paſſage of his Memoir, that he never could ſucceed in ſetting fire with the Acid of Vitriol to the white, æthereal Oil of Turpentine; that is, to the lighteſt which comes over firſt in diſtillation; but that the very ſame Acid ſet fire to "that which "comes over laſt in diſtillation, which is thick like a ſyrop, "and of a dark-brown colour."

All the experiments by which Oils have been fired, from thoſe of Beccher and Borrichius down to thoſe of Geoffroy and Hoffman, were made on the Eſſential Oils of the aromatic plants of India, which are the heavieſt we know, and on the empyreumatic Oil of Guaiacum, which, beſides being very ponderous, is alſo very thick.

Now theſe ſingular effects likewiſe agree perfectly well with our explanation. It is certain that the parts of a heavy fluid do not yield to any impulſe or ſhock, ſo eaſily as thoſe of a lighter fluid; juſt as the parts of a thick, viſcous fluid undoubtedly reſiſt any attempt to ſeparate them, ſo much the more the nearer the conſiſtence of that fluid is to ſolidity, or the further it is removed from the ſtate of fluidity. Now, the more reſiſtance the Acid meets with in ſeparating and dividing the parts of the Oil, as it muſt do to diſſolve them, the more conſiderable will be the force and motion with which it muſt neceſſarily act to ſurmount thoſe obſtacles; beſides, as experience teaches us that the denſity and viſcidity of the Oils do not, at leaſt to ſenſe, diminiſh the quickneſs and activity which the Acid exerts in uniting with them; the greater therefore muſt be the colliſions, frictions, and heat produced: and this plainly ſhews why heavy, thick Oils take fire, in this caſe, more readily than thoſe which are fluid and light.

It may here be objected, that Fat Oils, which are thicker and heavier than the light Eſſential Oils, take fire nevertheleſs with greater difficulty. This objection is eaſily anſwered, by obſerving, that when we ſay Acids fire heavy thick Oils with more eaſe than thin light Oils, this poſition muſt be reſtricted to Oils of the ſame kind, on which Acids have an equal, or nearly equal, action; that is, to ſuch Oils as differ from each other in no other reſpect but their thickneſs and weight.

For example, Mr. Homberg, who could by no means ſet fire, with Oil of Vitriol, to the Oil that riſes firſt in the diſtillation of Turpentine, found that the ſame Acid would fire the Oil that comes laſt over: and therefore it is reaſonable to attribute his ſucceſs, in firing this laſt Oil, to its being thicker and heavier than the former; ſeeing theſe two Oils are in other reſpects of the ſame nature; that Acids have an equal action on both; and that they differ from each other only in the qualities ſpecified above.

But it is evident, that, if the Oils compared together be of different kinds, and differ from each other, not only in weight and thickneſs, but alſo by containing different principles, or, at leaſt, the ſame principles combined differently, and in different proportions, the action of any Acid on thoſe Oils muſt alſo be different; and that regard muſt be had thereto in determining their degrees of inflammability.

Now all this is applicable to Fat Oils, when compared with light Eſſential Oils, in point of inflammability. If all theſe Oils were of the ſame nature, and differed from each other in weight and thickneſs only, the objection drawn from Fat Oils, which though thicker than Eſſential Oils do not take fire ſo eaſily, would be a very good one, and fact would be againſt our reaſoning. But this is far from being the caſe: the properties, as well as the analyſis, of Fat Oils ſhew their nature to be very different from that of Eſſential Oils; that there is more water in their compoſition; and that they are full of a mucilaginous or gummy principle, which muſt greatly obſtruct their inflammability, and the action of Acids upon them.

None of the effects, therefore, that attend the firing of Oils with Acids, is repugnant to our way of accounting for the phenomenon, which is one of the moſt beautiful in all Natural Philoſophy. To conclude this important ſubject, nothing now remains but to conſider the effects produced by the Vitriolic Acid in theſe accenſions.

This Acid, though of a ſtronger nature, and capable of being more highly concentrated than the Nitrous Acid, ſeems however leſs qualified to produce a flame with Oils. Indeed

Mr. Homberg fired Oil of Turpentine by mixing it with Oil of Vitriol: but I do not know that the experiment hath ſucceeded with any other Chymiſt; on the contrary, moſt of thoſe who have tried it affirm, that they never could fire any Oil with that Acid alone.

Oils are probably in the ſame caſe as metallic ſubſtances, with regard to theſe two Acids. We know that the Nitrous Acid diſſolves thoſe ſubſtances with vaſtly more activity and violence than the Vitriolic Acid exerts upon them; which may depend either on the diſpoſition and configuration of their parts, or on the portion of phlogiſton which, according to the opinion of moſt Chymiſts, is united with the Nitrous Acid, is its peculiar characteriſtic, and the cauſe of the great vivacity with which it diſſolves almoſt all matters that contain the phlogiſton.

I ſay *almoſt* all matters that contain the phlogiſton; becauſe there are ſome ſubſtances that contain a great deal thereof, and yet are not at all acted on by the pure Nitrous Acid. Theſe ſubſtances are matters perfectly charred: that is, ſuch as are capable of enduring the greateſt violence of fire in cloſe veſſels, without yielding a ſingle atom of Oil; that burn almoſt quite away, yet only grow red-hot without flaming; or at leaſt produce but a very ſmall, ſlight flame, from which it is impoſſible to obtain the leaſt particle of ſoot or fuliginoſity; in a word, that contain an inflammable matter, but ſuch as is fit to be an ingredient in the compoſition of metallic ſubſtances, to which the peculiar title of the Phlogiſton is appropriated.

I ſay, then, that if the Nitrous Acid be poured on a mere coal, perfectly charred, it is impoſſible for the Acid, be it ever ſo highly concentrated, to ſet the coal on fire, though heated before to the greateſt degree that it can poſſibly admit of without kindling; and, which is ſtill more remarkable, if a live coal be plunged into the moſt highly ſmoking Spirit of Nitre, it will be extinguiſhed as if dipt in pure water.

But to return to the Vitriolic Acid: it is ſingular enough that this Acid, which attacks Oils with leſs activity, and for that reaſon ſeems leſs fit to ſet them on fire, than the Nitrous Acid, yet greatly promotes their accenſion, when mixed with that very Acid. This may be owing to its rendering the Oils with which it mixes heavier and thicker; or elſe, as Mr. Rouelle conjectures with great probability, being more concentrated than the Nitrous Acid, and having a greater affinity with water, it dephlegmates the other, and thereby increaſes its activity; or, laſtly, this may ariſe from ſome other cauſe yet unknown to us, and perhaps from that by which the Acids of Nitre and of Sea-ſalt, which, when ſeparate and perfectly pure, can neither of them diſſolve Gold, are enabled, when combined together, to make a perfect ſolution of that metal.

PROCESS III.

To combine Eſſential Oils with Mineral Sulphur. Balſam of Sulphur. This Compoſition decompounded.

PUT into a matraſs one part of Flowers of Sulphur; pour on them ſix parts of the Eſſential Oil of Turpentine, for inſtance; ſet the matraſs in a ſand-bath, and heat it gradually till the Oil boil. The Sulphur, which at firſt lay at the bottom of the matraſs, will begin to melt, and appear to diſſolve in the Oil. When it hath boiled in this manner for about an hour, take the matraſs from the fire, and let the liquor cool. A great deal of the Sulphur that was diſſolved therein will ſeparate from it as it cools, and fall to the bottom of the veſſel in the form of needles, much like a Salt ſhooting in water.

When the liquor is perfectly cold, decant it from the Sulphur that lies at the bottom of the veſſel: to that Sulphur put freſh Oil of Turpentine, and proceed as before: the Sulphur will again diſappear, and be diſſolved in the Oil: but when the mixture is cold, you will find new cryſtals of Sulphur depoſited at the bottom. Decant once more this Oil from the cryſtals, and pour on freſh Oil to diſſolve them: continue the ſame method, and you will find that about ſixteen parts of Eſſential Oil are required to keep one part of Sulphur diſſolved when cold. This combination is called *Balſamum Sulphuris Terebinthinatum*, if made with Oil of Turpentine; *Aniſatum*, if with Oil of Aniſe-ſeeds; and ſo of others.

OBSERVATIONS.

ESSENTIAL Oils do not diſſolve Sulphur, in ſuch quantities, and with ſo much eaſe, as Fat Oils do. It was ſhewn above, that a Fat Oil is capable of keeping a conſiderable quantity of Sulphur in ſolution; whereas no leſs than ſixteen parts of Eſſential Oil are required to diſſolve one part only of Sulphur, as in this proceſs.

The property which Sulphur hath of ſeparating, in part, from the Eſſential Oil in which it is diſſolved, and falling to the bottom of the veſſel in the form of cryſtals, as the Oil cools, proves that it is a kind of Neutral Salt, which, being inſoluble in water, becauſe of the great quantity of inflammable matter that ſerves it for a baſis, is not to be diſſolved but by ſubſtances that actually contain themſelves a great deal of inflammable matter; ſuch as Oils and Metallic ſubſtances.

Though the latter are almoſt always ſolid, it nevertheleſs unites with ſeveral of them into regular forms, reſembling ſaline cryſtals in every thing but pellucidity; as appears, for example, in ſeveral Pyrites, Antimony, and ſome other ſulphureous minerals. But when it is diſſolved in Oils, eſpecially in ſuch as are capable of keeping but a ſmall quantity thereof in ſolution, and conſequently drop a good deal of it as they cool, it is preciſely in the caſe of one of thoſe Salts whereof hot water diſſolves more than cold; that is, the Oil, that is ſaturated with as much Sulphur as it can poſſibly take up when boiling hot, lets ſome part thereof precipitate as it cools; while the Sulphur thus ſeparated from the Oil unites into little glebes of a regular figure, and actually cryſtallizes; in the ſame manner as Nitre, when boiling water hath diſſolved as much thereof as it can poſſibly take up, partly ſeparates from it when it cools, and falls to the bottom of the veſſel in ſmall cryſtalline *moleculæ*, of the form peculiar to that Salt.

Mr. Homberg made ſome very curious experiments on this combination of Sulphur with an Eſſential Oil. In the Memoirs of the Academy he gives the following analyſis thereof.

" Put your Sulphur diſſolved by Oil of Turpentine into " a pretty large retort, becauſe the matter puffs up towards " the end, and diſtil with a very gentle heat for twelve or " fifteen days and nights. There will come over about two " thirds of the quantity of a colourleſs Oil of Turpentine, " and at the ſame time *a pretty conſiderable quantity* of a " whitiſh ponderous water, as acid as good Spirit of Vitriol. " After this, the drops of Oil that come off will begin to " be red. Then change your receiver, and increaſe the fire " gradually; and in ſeven or eight hours time, with a very " great heat, force off all that will riſe, uſing a glaſs retort " for your recipient. At laſt, moſt of the Oil will come " over into the receiver very thick and high-coloured, ſtill " accompanied with a whitiſh and very acid water. In the " retort will be left a black *caput mortuum*, ſpongy, or fo-

"liated, ſhining, and inſipid. . . . . This *caput mortuum* "neither grows white, nor flames, nor waſtes conſiderably "in a ſtrong fire.

"The matter that comes over into the receiver muſt be "diſtilled again, with a very gentle heat continued for ſeve- "ral days and nights, in order to ſeparate once more the "colourleſs Oil and the remaining acid water, till the Oil "begin to come off red. Then take the retort from the fire; "and on the black gummy matter left in it pour good Spi- "rit of Wine; mix the whole well together, and diſtil "with a very gentle heat. When this Spirit of Wine is "come off, pour ſome freſh on the black gum left in the re- "tort, and diſtil as before. Repeat this till the Spirit of "Wine ceaſe to have a bad ſmell."

There is great reaſon to believe, that, by the union which the Sulphur contracts with the Oil, the coheſion of the Acid and the Phlogiſton, which conſtitute that mineral, is conſiderably weakened; and that this is what occaſions the decompoſition of the Sulphur ſo manifeſt in Mr. Homberg's analyſis. The inflammable matter of the Sulphur is ſo incorporated with that of the Oil in the ſolution, that they form together one homogeneous whole; by which means the Acid of the Sulphur, which is of courſe diſperſed through the whole liquor, is not now combined with the Phlogiſton, as it was in the Sulphur before it was blended with the Oil; that is, with the pure Phlogiſton; but with that Phlogiſton which conſtitutes the oily mixture, or, which is the ſame thing, with actual Oil. And this is the reaſon that a compoſition of Oil and Sulphur yields, in diſtillation, nearly the ſame principles that a combination of the ſame Oil with the Vitriolic Acid would yield.

We have already ſeen, under the head of Fat Oils, that when Oils are combined with Acids, if this combination be again decompounded by diſtillation, thoſe two ſubſtances cannot be obtained in their original ſtate; but that they are changed and partly decompoſed. The caſe is the ſame in the experiment before us. We firſt get, by diſtillation, a pretty conſiderable quantity of Oil of Turpentine, that ſeems to have ſuffered no change at all. This firſt Oil is that which the action of fire ſeparates from the Acid; and this it effects with ſo much the more eaſe, that, a great quantity thereof having been neceſſarily uſed to diſſolve a little Sulphur, it greatly exceeds the quantity of Acid in the mixture, and that the diſtillation is ordered to be made with a very weak degree of heat: for M. Homberg ſays, it ought to be continued twelve or fifteen days and nights Now this manner of diſtilling, with a very gentle heat, is the moſt effectual means of ſeparating Oils, eſpecially light Eſſential Oils, from Acids; becauſe theſe Oils riſe in diſtillation with very little heat; whereas the Acids, being much more ponderous, require a great deal more.

The Oil that riſes firſt in diſtillation, appears indeed to be the ſame with that which was originally uſed in the mixture: but the quantity is much ſmaller: firſt, becauſe ſome part of it, being combined with the Acid of the Sulphur, is thereby rendered thick and heavy, which hinders it from riſing in this firſt diſtillation with a very gentle heat, and is the reaſon that it cannot be elevated without a much ſtronger degree of fire. It is this part that afterward comes over in the form of a red liquor upon increaſing the fire.

The ſecond cauſe why the quantity of Oil is leſſened, is, that part of it is decompoſed in the operation. This decompoſed part of the Oil furniſhes that conſiderable quantity of water which aſcends at the ſame time with the Oil, or a little after it, and ſerves for a vehicle to the Acid that riſes with it in this firſt diſtillation; which Acid, though pretty ſtrong, is now much more loaded with water than when it was an ingredient in the combination of Sulphur. This acid water is of a milky white colour, becauſe many oily particles are ſuſpended and diffuſed in it, but not perfectly diſſolved.

The *caput mortuum* that is left in the retort, after all the red thick Oil is driven up by a very ſtrong degree of fire, is a ſort of charred matter, conſiſting of ſome of the earth of the Sulphur, and of the decompoſed Oil, united with a phlogiſton, which is probably furniſhed by both theſe ſubſtances. This matter contains alſo a little Acid fixed with it. This Acid reproduces Sulphur, or at leaſt becomes ſulphureous, and flies off in vapours, when the coal is urged by a violent forge-heat: for Mr. Homberg obſerved, that by this means it exhaled an odour of Sulphur, and loſt in weight.

This charred matter is of a ſingular nature: for, by being expoſed to a forge-heat, and even to the heat in the focus of a burning glaſs, it ſeemed to ſuffer no other change than ſome loſs of weight, occaſioned by the evaporation of the acid effluvia carried off by the heat; for it ſtill retained its black colour, and was neither conſumed nor vitrified. In order to melt it, Mr. Homberg was forced to mix it with Borax. This Salt converted it into a glaſs of a dark-grey colour: and, as there appeared a little verdegris on the ſurface

face of this glaſs after keeping it in a moiſt place, he thereby found that the Sulphur he had uſed contained a little Copper.

We know that the earth of Copper is refractory, and that it communicates a dark colour to matters vitrified along with it: and perhaps it was the cauſe why the fixed matter in queſtion retained its blackiſh colour ſo obſtinately, notwithſtanding the phlogiſton that muſt have been in it at firſt was, in all probability, conſumed by the violent ignitions it underwent.

As to the thick oily matter, called *gummy* by Mr. Homberg, from which he directs Spirit of Wine to be repeatedly diſtilled, till it ceaſe to have a diſagreeable ſmell, there is great reaſon for thinking it to be, as we ſaid before, a portion of the Oil which the Acid hath rendered thick and heavy. The Spirit of Wine diſſolves and carries up the moſt acid part, which always hath a diſagreeable ſmell.

Mr. Homberg ſays, that " the part remaining after this, " which he calls the *Gum of common Sulphur*, hath a plea- " ſant balſamic odour; that it partly diſſolves in Spirit of " Wine, a hard reſinous matter being left, which will not " diſſolve, either in Spirit of Wine, or in the ſtrongeſt lixi- " vium." Of conſequence, therefore, it is neither a reſinous matter nor a ſulphur; " yet it diſſolves perfectly in di- " ſtilled Oils." What then is this ſingular body? It is certainly a ſubject for very curious inquiries. In general, Mr. Homberg's whole proceſs is full of intereſting facts, and well deſerves to be repeated, carried further, and carefully attended to.

PROCESS IV.

To combine Eſſential Oils with Fixed Alkalis. Starkey's Soap.

TAKE Salt of Tartar, or any other Alkali, thoroughly calcined. Heat it in a crucible till it be red, and in that condition throw it into a hot iron mortar: rub it quickly with a very hot iron peſtle; and as ſoon as it is powdered pour on it, little by little, nearly an equal quantity of Oil of Turpentine. The Oil will enter into the Salt, and unite intimately with it, ſo as to form a hard paſte. Continue rubbing this compoſition with the peſtle, in order to complete the union of the two ſubſtances; and, as your Oil of Turpentine diſappears, add more, which will unite in the ſame manner, and give a ſofter conſiſtence to the ſoapy maſs. You may add ſtill more Oil, according to the conſiſtence you intend to give your Soap.

OBSERVATIONS.

ESSENTIAL Oils do not unite near ſo eaſily as Fat Oils with Alkalis. For this reaſon, to make a Soap with an Eſſential Oil, we muſt take a method different from that uſed in common ſoaperies. For if an Eſſential Oil be ſubſtituted for the Fat Oil, in the ordinary way of making Soap, far from combining with the alkaline lixivium, though ever ſo ſtrong, it will be wholly diſſipated and vaniſh: ſo that, after boiling ſome time, you will find nothing but the lye, juſt as when firſt put in, only a little more concentrated.

The water, in which the Alkali is diſſolved when in the form of a lye, is the principal thing that hinders the Salt from uniting with the Eſſential Oil. Water is ſuch an enemy to this union, that, if the Alkali be ever ſo little moiſt, the operation will not ſucceed; even though all the other precautions mentioned in the proceſs ſhould be exactly obſerved.

In order, therefore, to free the Alkali from all humidity, it is neceſſary to begin with making it red-hot; and then, that this Salt, which is very greedy of moiſture, may not imbibe any from the air, before it be mixed with the Eſſential Oil, it muſt not be ſuffered to cool; but the mixture muſt be made in a hot veſſel, as ſoon as the Salt is reduced to powder. When every particle of the Salt is once covered with Oil, you need not fear its attracting any moiſture, at leaſt very quickly, becauſe the Oil oppoſes its admiſſion.

Starkey, the firſt Chymiſt who found the means of making Soap with an Eſſential Oil, and by whoſe name this kind of Soap is therefore called, made uſe of a much more tedious method than that propoſed in our proceſs. He began with mixing a very ſmall quantity of Oil with this Salt, and waited till all the Oil united therewith of its own accord, ſo as to diſappear entirely, before he added any more; and thus protracted his operation exceedingly, though in the main it was the ſame with ours. The method here propoſed is more expeditious, and was invented by Dr. Geoffroy.

Starkey's Soap diſſolves in water much as common Soap does, without any ſeparation of the Oil: and by this mark it is known to be well made. It may alſo be decompounded, either by diſtillation, or by mixing it with an Acid: and its decompoſition, in either of theſe ways, is attended with nearly the ſame phenomena as the decompoſition of common Soap.

CHAP. VI.

Of the SUBSTANCES *obtained from* VEGETABLES *by Means of a* GRADUATED HEAT, *from that of boiling Water, to the ſtrongeſt that can be applied to them in cloſe Veſſels.*

PROCESS I.

To analyze Vegetable Subſtances that yield neither a Fat nor an Eſſential Oil. Inſtanced in Guaiacum-Wood.

TAKE thin ſhavings of Guaiacum-wood, and put them into a glaſs or ſtone retort, leaving one half thereof empty. Set your retort in a reverberating furnace, and lute on a large glaſs receiver having a ſmall hole drilled in it; ſuch as is uſed for diſtilling the Mineral Acids. Put a live coal or two in the furnace, to warm the veſſels gently and ſlowly.

With a degree of heat below that of boiling water, you will ſee drops of a clear inſipid phlegm fall into the receiver. If you raiſe the fire a little, this water will come ſlightly acid, and begin to have a pungent ſmell. With a degree of fire ſomewhat ſtronger, a water will continue to riſe which will be ſtill more acid, ſmell ſtronger, and become yellowiſh. When the heat comes to exceed that of boiling water, the phlegm that riſes will be very acid, high coloured, have a ſtrong pungent ſmell, like that of matters long ſmoked with wood in a chimney, and will be accompanied with a red, light Oil, that will float on the liquor in the receiver.

And now it is neceſſary that the operation be carried on very cautiouſly, and vent frequently given to the rarefied air by opening the ſmall hole in the receiver: ſuch an incredible quantity thereof ruſhing out of the Wood, with this degree of heat, as may burſt the veſſels to pieces, if not diſcharged from time to time.

When this red, light Oil is come over, and the air ceaſes to ruſh out with impetuoſity, raiſe your fire gradually, till the retort begin to redden. The receiver will be filled with denſe vapours; and, together with the watery liquor, which will then be extremely acid, there will riſe a black, thick, ponderous Oil, which will fall to the bottom of the receiver, and lye under the liquor.

Then give the utmoſt degree of heat; that is, the greateſt your furnace will allow, and your veſſels bear. With this exceſſive heat a little more Oil will riſe, which will be very ponderous, as thick and black as pitch; and the veſſels will continue full of vapours that will not condenſe.

At laſt, when you have kept the retort exceeding red for a long time in this extremity of heat, ſo that it begins to melt, if it be of glaſs, and you perceive nothing more come over, let the fire go out and the veſſel cool. Then take off your receiver: from the black oil at bottom decant the acid liquor with the red Oil floating on it, and pour them both into a glaſs funnel, lined with brown filtering paper, and placed over a bottle. The acid liquor will paſs through the filter into the bottle, and the Oil will be left behind, which muſt be kept by itſelf in a ſeparate bottle. Laſtly, into another funnel, prepared as the former, pour the thick Oil remaining with a little of the acid liquor at the bottom of the receiver. This liquor will filter off in the ſame manner, and thus be ſeparated from the heavy Oil.

In the retort you will find your Guaiacum-ſhavings, not in the leaſt altered as to their figure, but light, friable, very black, ſcentleſs, and taſteleſs, eaſily taking fire, and conſuming without flame or ſmoke; in ſhort, you will find them charred to a perfect coal.

OBSERVATIONS.

HITHERTO we have examined the ſubſtances that may be obtained from vegetables, either without the help of fire, or with a degree of heat not exceeding that of boiling water. The analyſis of plants can be carried no further without a greater degree of heat: for, when the principle of odour, and the eſſential oil of an aromatic plant, are wholly extracted by the preceding proceſſes, if the diſtillation be afterward continued without increaſing the heat, nothing more will be obtained but a little Acid; which will ſoon ceaſe, as a ſmall part only of the quantity contained in the plant will be elevated; the reſt being either too ponderous, or too much entangled with the other principles of the body, to riſe with ſo ſmall a degree of heat.

In order, therefore, to carry on the decompoſition of a plant, from which you have, by the methods before propoſed, extracted all the principles it is capable of yielding when ſo treated; or, which comes to the ſame thing, in order to analyze a vegetable matter, which affords neither an expreſſed nor an eſſential oil, it muſt be diſtilled in a retort with a naked fire, as directed in the proceſs, and be made to undergo all the degrees of heat ſucceſſively, from that of boiling water, to the higheſt that can be raiſed in a reverberating furnace

A heat inferior to that of boiling water, with which we muſt begin in order to warm the veſſel gradually, brings nothing over, as hath been ſaid, but an inſipid water, deſtitute of all acidity. By increaſing it nearly to the degree of boiling water, the diſtilled water comes to be ſlightly acid.

When the heat is made a little ſtronger than that which is neceſſary for the elevation of an Eſſential Oil, the acidity of the water that comes off is much more conſiderable. It hath now both colour and ſmell, and there riſes with it a red, light Oil, that floats on the liquor in the receiver. This is not an Eſſential Oil; it hath none of the odour of the plant. Though ſo light as to float on water, yet it will not riſe with the degree of heat that raiſes Eſſential Oils; even thoſe that much ſurpaſs it in gravity, and will not ſwim on water as this does. This proves that the eaſe or difficulty, with which a particular degree of heat raiſes any ſubſtance in diſtillation, doth not depend altogether on its gravity: its dilatability, or the volatile nature of the matters, with which it is ſo cloſely united as not to be ſeparated from them by diſtillation, may probably contribute greatly to produce this effect.

It is very ſurpriſing that a ſubſtance ſo hard, ſo compact, ſo dry, in appearance, as Guaiacum-wood, ſhould yield ſuch a large quantity of water by diſtillation; and it is equally ſo, that it ſhould diſcharge ſo much air, and with ſo much impetuoſity, as nothing but experience could render credible. We have, in the proceſs, directed the precautions to be taken when this air, from being prodigiouſly condenſed in the body of which it made a part, is ſet at large, ruſhes out of confinement, and expands with all its natural elaſticity. From this air ariſes the greateſt danger attending the operation.

It hath been remarked, that the heavieſt and moſt compact woods yield the moſt air in diſtillation: and accordingly Guaiacum-wood, which we have choſen for an inſtance, as exceeding almoſt all others in hardneſs and weight, diſcharges a vaſt quantity of air when analyzed.

The thick, burnt, empyreumatic Oil, that comes over laſt in this diſtillation, is heavier than water; on account, probably, of the great quantity of Acid with which it is replete. The two kinds of Oil obtained in this analyſis may be rectified, by diſtilling them a ſecond time, or rather ſeveral times; by which means they will become lighter and more fluid, as we have ſeen happen to Fat and Eſſential Oils. In general, all thick, heavy Oils conſtantly owe theſe qualities to an Acid united with them; and it is by being freed from ſome of that Acid in diſtillation, that they always acquire a greater degree of lightneſs and fluidity from that operation. To theſe laws all vegetable Oils are ſubject, of what nature ſoever they be.

The analyſis of a vegetable ſubſtance, exhibited above, ſhews what may be obtained from them, when diſtilled in cloſe veſſels, with a graduated heat, from that of boiling water, to that which converts the mixt to a perfect coal; viz. Phlegm, an Acid, a light Oil, much Air, and a thick Oil. But this analyſis is far from being a complete one: it may be carried much farther, and made more perfect.

None of the principles obtained by this analyſis are pure, ſimple, and thoroughly ſeparated from the reſt. They are ſtill in ſome meaſure blended all together: their ſeparation is but begun; and each requires a ſecond and more accurate analyſis, to reduce it to the greateſt degree of purity of which it is capable. The Oil and the Acid chiefly merit ſo much pains.

A great deal of the Acid of the plant remains, as was ſaid, combined with the two ſorts of Oil here obtained; which we have reaſon to think differ no otherwiſe from one another, than as there is more or leſs Acid united with each. The beſt way of freeing theſe Oils from their redundant Acid is to diſtil them frequently from Alkalis and Abſorbents. Some of our beſt Chymiſts have taken this pains with ſeveral ſorts of Oils; but the method might be ſtill extended, and the operation carried further than hath yet been done.

The Acid is in the ſame circumſtances nearly as the Oil. The firſt that riſes is mortified with much water, to which it owes a good deal of its volatility. That which comes over laſt is much more concentrated, and conſequently heavier; yet it is ſtill very aqueous. It might be freed in a great meaſure from this adventitious water, and ſo rendered much ſtronger; which would give us a better opportunity to diſcover its nature and properties, of which we know but very little.

Water is not the only heterogeneous ſubſtance that diſguiſes the vegetable Acid: a pretty conſiderable quantity of the Oil of the plant is alſo combined with it, and contaminates its purity. The proof of this is, that, when theſe Acids are kept, in the ſame condition in which they firſt come over, for any length of time, in a glaſs veſſel, they gradually depoſite, on the bottom and ſides of the veſſel, an oily incruſtation, which grows thicker and thicker the longer it ſtands; and, as this oily matter ſeparates from it, the Acid liquor appears leſs unctuous and ſaponaceous.

A very good way to ſeparate this Oil more effectually from the Acid is to combine the whole with abſorbents, and abſtract the Oil again by diſtillation. By this means a very ſenſible quantity of Oil may be ſeparated that was not perceived before. On this occaſion it is proper to remark, that the Oil thus united with the vegetable Acid is perfectly diſſolved by it; ſeeing it is thereby rendered miſcible with water, ſo that it doth not, like Alkaline ſoaps, in the leaſt obſcure its limpidity, or give it a milky caſt: for theſe aqueous, oily Acids are very tranſparent, eſpecially after they have ſtood for ſome time.

The air that is diſcharged with impetuoſity in the operation, and muſt be let out, is loaded with many particles of Acid and Oil reduced to vapours, which it carries off; and by this means the quantity of the principles extracted from the mixt cannot be accurately determined: nor are the vapours, of which the veſſels remain full after the operation, any other than particles of Acid and Oil, which the violence of the fire hath rarefied exceedingly, and which do not eaſily condenſe.

If we diſtil in this manner a vegetable aromatic ſubſtance, which of courſe contains an Eſſential Oil, provided it hath not been previouſly extracted by the appropriated proceſs, this Eſſential Oil will riſe firſt, as ſoon as the diſtilling veſſel acquires the heat of boiling water: but its ſcent will not be near ſo ſweet or grateful, as if it were diſtilled in the manner before directed as propereſt for it. On the contrary, it will have an empyreumatic ſmell: becauſe in this way it is impoſſible to avoid ſcorching and half-burning ſome of the matter diſtilled; eſpecially that part of it which touches the ſides of the retort. Moreover, the very ſame equable degree of heat can hardly be kept up with a naked fire. The Eſſential Oil, therefore, though it riſes firſt, will not be pure, but contaminated with a mixture of the empyreumatic Oil that firſt comes over, and will be confounded therewith.

If a ſubſtance abounding with Fat Oil, that hath not been expreſſed from it, be diſtilled according to the preſent proceſs, it will yield no Fat Oil by diſtillation; but only much more of the firſt clear Oil, and of the ſecond thick Oil, than if all the Fat Oil it would have afforded had been firſt drawn off by expreſſion: for as the Fat Oil will not riſe in diſtillation, without a degree of heat greater than that of boiling water, neither can it endure ſuch a degree of heat without changing its nature, without loſing that mildneſs, and, in a great meaſure, that unctuoſity which is natural to it. It will therefore be confounded with the other empyreumatic Oil, which, in all probability, would itſelf be no other than a Fat Oil, if it could be wholly extracted, without the aid of fire, from the vegetable ſubſtances containing it.

Moſt vegetable ſubſtances, when diſtilled with a ſtrong fire, yield the ſame principles with that which we have choſen for an inſtance. Entire plants of this kind, thoſe from which the odorous principle, the Eſſential Oil, or the Fat Oil, hath been drawn, thoſe of which extracts have been made by infuſion or decoction, or the extracts themſelves; all ſuch matters being diſtilled yield a Phlegm, an Acid, a thin Oil, Air, and a thick Oil. and the products of their ſeveral analyſes differ from each other, only on account of the different quantity or proportion that each contains of the principles here enumerated.

But there are many other plants, which, beſides theſe ſubſtances, yield alſo a conſiderable quantity of a Volatile Alkaline Salt. This property is poſſeſſed chiefly by that tribe of plants which is diſtinguiſhed by having cruciform flowers; among which there are ſome that being analyzed greatly reſemble animal matters. We ſhall now analyze one of theſe; Muſtard-ſeed, for inſtance.

PROCESS II.

To analyze a vegetable Subſtance which yields the ſame Principles as are obtained from Animal Matters; inſtanced in Muſtard-ſeed.

WITH an apparatus like that of the preceding proceſs, and with the ſame fire, diſtil Muſtard-ſeed. With a degree of heat inferior to that of boiling water, there will come over a phlegm ſomewhat coloured, and impregnated with a Volatile Alkaline Salt. With a degree of heat greater than that of boiling water, the ſame kind of phlegm, impregnated with the ſame Salt, will continue to come over; but it will be much higher coloured, and will be accompanied with a light Oil. At this time a conſiderable quantity of air is diſcharged; with regard to which the ſame precautions muſt be taken as in diſtilling Guaiacum.

If the fire be gradually raiſed, there will come over a black thick Oil, lighter however than water; and at the ſame time vapours will riſe, and, condenſing on the ſides of the receiver, form into ſprigs or ramifications. This is a Volatile Alkaline Salt, in a concrete form, like that of animals, as we ſhall hereafter ſee. Theſe vapours are much whiter than thoſe of Guaiacum.

When you have thus drawn off, with a very ſtrong fire, all the Volatile Alkali and thick Oil contained in the ſubject, there will be nothing left in the retort but a ſort of coal, from which a ſmall quantity of phoſphorus may be obtained, provided the retort you employ for that purpoſe be good enough to ſtand a very violent heat.

OBSERVATIONS.

MUSTARD-SEED furniſhes us with an inſtance of a vegetable, from which we obtain, by analyzing it, the very ſame principles that animal matters yield. Inſtead of getting an Acid from it, we obtain only a Volatile Alkali; probably becauſe the Acid, which originally enters into the compoſition of this kind of vegetables, as well as of all others, undergoes in paſſing through their ſtrainers, and mixing with their juices, ſuch alterations as it ſuffers when it enters into the compoſition of animals: that is, it combines with ſome of their Earth and of their Oil, in ſuch a manner as to be changed into a Volatile Alkali, or at leaſt diſpoſed to be converted into one with the aid of fire.

We ſhall not here ſpeak of the manner of ſeparating and depurating the principles obtained by this proceſs; but reſerve it for the analyſis of animals, which is abſolutely the ſame. We ſhall content ourſelves with obſerving, that the firſt Volatile Alkali which riſes at the beginning of the operation together with the phlegm, in a degree of heat below that of boiling water, differs from that which doth not come over till towards the end of the diſtillation, when the laſt thick Oil aſcends. The different times, and different degrees of heat, in which theſe two Alkalis riſe, ſhew that the former exiſts actually and perfectly in the plant; but that the latter is generated during the diſtillation, and is the product of the fire, which combines together the materials whereof it is compoſed.

Vegetables that thus yield a Volatile Alkali with a heat leſs than that of boiling water, irritate the organ of ſmelling, affecting it with a ſenſation of acrimony; and the effluvia, which riſe from them when bruiſed, make the eyes ſmart ſo as to draw tears from them in abundance. Several of theſe matters, being only bruiſed, efferveſce with Acids: effects producible only by a very Volatile Alkaline principle.

This is that Alkali, the lighteſt of all the principles that can be extracted from bodies, which riſes firſt in our diſtillation along with the phlegm, and with a degree of heat much inferior to that of boiling water. As the phlegm with which it riſes is very copious, it is diſſolved thereby; which is the reaſon it doth not appear in a concrete form. To this water it gives a ſlight yellowiſh tinge, becauſe it is impure and oily. The ſaline Alkaline properties of this liquor have procured it the title of a Volatile Spirit. This Volatile Alkali, which exiſts naturally and perfectly formed in Muſtard-ſeed, Onions, Garlic, Creſſes, and other ſuch vegetables, conſtitutes a difference between them and animal ſubſtances, which contain only the materials requiſite to form a Volatile Alkali, but none ready formed, unleſs they have undergone the putrid fermentation.

The ſecond Volatile Alkali which riſes in our diſtillation, but not without a very ſtrong degree of fire, and at the ſame time with the laſt thick Oil, ſeems to be a production of the fire; for if it were already formed in the mixt, as the other is, it would riſe with the ſame heat, and at the ſame time, being equally volatile. It is not impoſſible, however, that it may exiſt perfectly formed in the plant; but, having contracted an union with ſome Acid, and therewith compoſing an Ammoniacal Salt, it may by that means be hindered from riſing ſo readily as is agreeable to its natural volatility.

The Phoſphorus obtained by a violent fire, from the *caput mortuum* of this diſtillation, ſeems to throw a light of probability on this conjecture. There is certainly a great deal of Acid in the compoſition of Phoſphorus. Perhaps this Acid was originally combined with our ſecond Volatile Alkali, and formed therewith, as was ſaid, a ſort of Sal Ammoniac. Moreover, almoſt all the plants that yield a Volatile Alkali by diſtillation, yield alſo a conſiderable quantity of Acid: which may perhaps be the remains of ſuch a Sal Ammoniac decompoſed by the operation. This is a ſubject for curious and uſeful inquiries. This ſecond Volatile Alkali appears in a concrete form, becauſe very little phlegm comes over along with it; ſo that the vapours thereof are not ſufficient to diſſolve it, as they did the firſt.

CHAP. VII.

Of the SUBSTANCES *obtained from* VEGETABLES *by* COMBUSTION.

PROCESS I.

To procure a Fixed Cauſtic Alkaline Salt from a Vegetable Subſtance, by burning it in the open Air.

TAKE any vegetable matter whatever; ſet it on fire, and let it burn in the open air till it be wholly reduced to aſhes. On theſe aſhes pour a quantity of boiling water ſufficient to drench them thoroughly. Filter the liquor in order to ſeparate the earthy parts; and evaporate your lye to dryneſs, ſtirring it inceſſantly; and you will have a yellowiſh-white Salt.

Put this Salt in a crucible; ſet it in a melting furnace, and make a moderate fire, ſo as not to fuſe the Salt. It will turn firſt of a blue-grey colour, afterwards of a blue-green, and at laſt reddiſh. Put on the dome of the furnace; fill it with coals; make your fire ſtrong enough to melt the Salt, and keep it in fuſion for an hour, or an hour and half. Then pour it into a heated metal mortar; pound it while it is red-hot; put it, as ſoon as poſſible, into a glaſs bottle, firſt made very hot and dry, and ſhut it up cloſe with a glaſs ſtopple rubbed with emery. By this means you will have the pure Fixed Alkali of the vegetable ſubſtance you burnt.

OBSERVATIONS.

BURNING a vegetable ſubſtance in the open air is a kind of violent and rapid analyſis made by fire, which ſeparates, reſolves, and decompoſes, ſeveral of its principles.

When any wood or plant is laid on a quick fire, there aſcends from it immediately an aqueous ſmoke, which conſiſts of little more than phlegm; but this ſmoke ſoon becomes thicker and blacker: it is then pungent, draws tears from one's eyes, and excites a cough if drawn into the lungs with the breath. Theſe effects ariſe from its being replete with the Acid, and ſome of the Oil, of the vegetable converted into vapours. Soon after this the ſmoke grows exceeding black and thick: it is now ſtill more acrid, and the plant turns black. Its ſtrongeſt Acid and laſt thick Oil are now diſcharged with impetuoſity.

This rarefied Oil being heated red-hot ſuddenly takes fire and flames. The vegetable burns and deflagrates rapidly, till all its Oil is conſumed. Then the flame ceaſes; and nothing remains but a coal, like that found in a retort after all the principles of a plant have been extracted by the force of fire. But this coal having a free communication with the air, which is abſolutely neceſſary to keep a combuſtible burning, continues to be red, ſparkles, and waſtes, till all its phlogiſton is diſſipated and deſtroyed. After this nothing remains but the Earth and Fixed Salt of the vegetable; which, mixed together, form what we call the Aſhes. Water, which is the natural ſolvent of Salts, takes up every thing of that kind that is contained in the aſhes; ſo that, by lixiviating them, as directed, all the Salt is extracted, and nothing left but the pure earth of the mixt which is thus decompoſed.

The phenomena obſerved in the burning of a vegetable ſubſtance, and the production thereby of a Fixed Alkali, ſeem to prove that this ſalt is the work of the fire; that it did not exiſt in the plant before it was burnt; that the plant only contained materials adapted to form this Salt; and that this Salt is no other than a combination of ſome of the Acid, united with a portion of Earth, by means of the igneous motion.

In the firſt place; a Fixed Alkali may be obtained by lixiviation from the aſhes of all vegetable matters that contain an Acid, Earth, and Phlogiſton, in due proportion. Thus Eſſential Salts; the ſubſtance of extracts made by trituration, infuſion, or decoction; wood coals burnt to aſhes; all yield a quantity of this Salt in proportion to the quantity of Acid and Earth contained in them.

Secondly; Fat, Eſſential, and Empyreumatic Oils afford, when burnt, ſuch a ſmall quantity of Fixed Alkali as is ſcarce perceptible; becauſe they contain but a little Acid, and ſtill leſs Earth: and theſe ſame Oils, when rectified by repeated diſtillations, and then burnt, leave ſtill leſs of this

Salt; becauſe they are ſeparated by rectification from moſt of the Acid, together with the ſmall matter of Earth contained in them.

Thirdly; thoſe vegetable matters which, being analyzed, furniſh a great deal of Volatile Alkali, yield but very little Fixed Alkali; becauſe a great deal of their Acid is employed in forming the Volatile Alkali, which is diſſipated by burning the plant: and, for the ſame reaſon, thoſe which in diſtillation afford only a Volatile Alkali, and no Acid, leave in their aſhes little or no Fixed Alkali, as is alſo the caſe with animal matters.

Fourthly, and laſtly; the aſhes of ſuch plants as have been long ſteeped in water, and from which infuſions and decoctions have been made, always contain the leſs Alkali the longer they have been infuſed or boiled, and the more water they were infuſed or boiled in; becauſe water diſſolves and carries off their Acid. It is for this reaſon that the aſhes of float-wood are much leſs ſaline than thoſe of green wood. Boerhaave aſſures us, in his Chymiſtry, that having exhauſted Roſemary by repeated decoctions, and having afterwards boiled the plant thus treated, the aſhes produced by it ſhewed not the leaſt ſign of a Fixed Alkali. He ſays, that, in order to exhauſt thoroughly all the ſaline matters contained in Roſemary, he was obliged to decoct it no leſs than twenty times ſucceſſively, with freſh water every time, and never ceaſed boiling it in this manner, till he was ſure that the water, by boiling the plant in it for a long time, took up from it no kind of matter whatever that in the leaſt affected its purity: ſo that the water of his laſt decoction had abſolutely no ſmell, taſte, or colour; but was in ſhort preciſely the ſame as before he uſed it for the decoction. The ſame author obſerves, that his plant, after having been exhauſted in this manner, and having ſuffered ſuch continued boiling, retained nevertheleſs its perfect external form; that from being green at firſt it became brown, and ſunk to the bottom of the water, inſtead of floating thereon as it did before decoction.

If, in reiterating this beautiful experiment of Mr. Boerhaave's, you ſhould not ſucceed as you expect, you muſt not therefore accuſe this great man of having been miſtaken on this occaſion; ſeeing it is very difficult, not to ſay impoſſible, to aſcertain exactly, from the account he hath given of his experiment, all that is neceſſary to its perfect ſucceſs: for he hath not ſpecified either the duration of the coctions which he made the Roſemary undergo, or the quantity of water he employed in each; whereas a difference in either of theſe may occaſion a vaſt difference in the reſult. It is evident, that if five or ſix pounds of water be uſed for each coction of a pound of Roſemary, and be kept boiling for two or three hours, the plant will not be near ſo much exhauſted by being ſo treated, as if the ſame quantity thereof were kept boiling for ſeveral days in forty or fifty quarts of water.

Indeed, theſe points ſeem, in ſome meaſure, to be determined, by what he ſays of the quality which the water of the laſt decoction ought to have. But the ſame objections occur here alſo; nay, the two circumſtances of the quantity of water and the duration of the boiling, have the greateſt influence here: for the more a plant is exhauſted of its Salts, the more difficult it becomes for the water to diſſolve and ſeparate the ſmall quantity thereof that remains united with the tenacious Oil; and conſequently it may happen, that this laſt water, after the plant hath boiled in it five or ſix hours, ſhall appear inſipid, ſcentleſs, colourleſs; and yet that a much greater quantity of water, but reduced by longer boiling to the ſame quantity with that which hath been boiled but five or ſix hours, ſhall have acquired both taſte and colour; in a word, ſhew that it hath taken up ſome of the principles of the plant. It may alſo happen, that, a ſmall portion of ſaline matter being diffuſed through a large quantity of water, after long continued coction, ſhall not be perceptible either to the taſte or to the eye; but that the very ſame portion of ſaline matter ſhall become very ſenſible, when the quantity of water in which it is loſt, as it were, is ſufficiently leſſened by evaporation.

Hence, if we would make ſure of fulfilling the conditions required by Mr. Boerhaave, the laſt decoction of the plant muſt be made in a much greater quantity of water, and continued for a much longer time, than may perhaps be imagined, or perhaps eaſily determined; and this decoction being evaporated to any degree you pleaſe, muſt have neither taſte, ſmell, nor colour: in ſhort, it muſt from firſt to laſt remain perfectly like pure water. In other words, it is very difficult to attain to any certainty in this matter.

Though what hath hitherto been ſaid, about procuring the Fixed Alkali of plants by combuſtion, ſeems to prove that this Salt is wholly the production of the fire, yet it muſt not be aſſerted that no part thereof pre-exiſted formally in the plant before it was burnt. On the contrary, it is certain that, amongſt the ſaline matters found in the compoſition of plants, there are true Neutral Salts whoſe baſis is a Fixed Alkali; but this Alkali being combined with an Acid diſcovers none of its properties, and never appears in its true form till the Neutral Salt, of which it makes a part, is decompoſed by combuſtion. The caſe of Sea-plants, all of which contain Sea-ſalt, and when burnt yield an Alkaline Salt perfectly reſembling the baſis of Sea-ſalt, ſeems to decide this point.

If, in lixiviating the aſhes of a plant, to diſſolve and waſh out its Alkali, you intend that nothing ſhould be left but an abſolutely pure earth, fit for making cupels, you muſt not be contented with one ablution only, even with a large quantity of water; becauſe the aſhes continue drenched with the water in which the Salts are diſſolved, and conſequently, when this water is evaporated, ſome of the Salts will be left with the earth. Therefore, if this be your view, you muſt waſh it three or four ſeveral times, uſing freſh water every time.

The water impregnated with the Alkali cannot be evaporated without a conſiderable loſs of Salt, eſpecially if it be violently boiled; becauſe the water, with which it is cloſely united, carries off part of it. In conſequence of this intimate union, it is very difficult, when the evaporation is near finiſhed, and but a little water left, to dry the Salt perfectly, becauſe it pertinaciouſly retains this laſt portion of humidity.

The Alkali obtained from the aſhes of a burnt plant is not perfectly pure: it is contaminated with a ſmall mixture of fatty matters, which were probably defended thereby againſt the action of the fire, and which render it ſomewhat ſaponaceous. In order to free it from this extraneous matter, and to render it very cauſtic, it muſt be calcined a long time in a crucible, but without melting it at firſt: becauſe it is with this Salt as with moſt metallic matters, which are ſooner and more eaſily deprived of their phlogiſton by being calcined without melting, provided they be comminuted into ſmall particles, than when they are in fuſion; all melted matters having but a ſmall ſurface expoſed to the air, by the contact of which the evaporation of any thing whatever is exceedingly promoted. It was for this reaſon we directed the Salt to be calcined for a long time in a crucible before melting it.

Mr. Boerhaave was very ſenſible of the utility of this calcination of the Alkali previous to its being melted, when in his Chymiſtry he ordered the aſhes containing this Salt to be put into a large earthen veſſel, kept red-hot for a conſiderable time, taking great care that the Salt do not melt. He takes notice, that, the longer the aſhes are calcined in this manner, the ſtronger is the Alkali obtained from them.

This method is, in the main, the very ſame with that here preſcribed, and produces the ſame effect; becauſe the Alkali is equally well freed of the extraneous fatty matter, whether it be calcined before or after its ſeparation, provided it be not ſuffered to melt.

Mr. Boerhaave gives another reaſon for recommending care to be taken that the Fixed Alkali do not melt, while the aſhes are calcining to render it ſtronger and more cauſtic: for, if that ſhould happen, the melted mixture of the Salt and aſhes would produce a vitrified maſs, which would have none of the properties of the Salt.

PROCESS II.

To procure the Fixed Salt of a Plant, by burning it after the manner of Tachenius.

INTO an iron pot put the plant whoſe Salt you deſire to obtain in the manner of Tachenius, and ſet it over a fire, ſtrong enough to make its bottom red-hot; at the ſame time cover your plant with a plate of iron, that may lie immediately upon it in the pot. The plant will grow black, and ſmoke conſiderably; but will not flame, becauſe it hath not a ſufficient communication with the air. The black ſmoke only will eſcape through the interſtice left between the ſide of the pot and the rim of the plate; which, for that purpoſe, ſhould be made ſo as not to fit exactly into the pot. From time to time take up the iron plate, ſtir the plant, and cover it again immediately, to prevent its taking fire, or to ſmother it if it ſhould happen to flame: go on thus till the black ſmoke ceaſe.

Then take off the iron plate: the upper part of the half-burnt plant will take fire as ſoon as the air is admitted, conſume gradually, and be reduced to a white aſh. Stir your matter with an iron wire, that the undermoſt parts, which are ſtill black, may be ſucceſſively brought uppermoſt, take fire, and burn to white aſhes. Go on thus as long as you perceive the leaſt blackneſs remaining. After this, leave your aſhes ſome time longer on the fire; but ſtir them frequently, to the end that, if any black particles ſhould ſtill be left, they may be entirely conſumed.

Your aſhes being thus prepared, lixiviate them with ſeven times their quantity of water, made to ſimmer over the fire, and keep ſtirring it with an iron ladle. Then filter the liquor,

quor, and evaporate it to dryneſs in an iron pot, ſtirring it inceſſantly towards the end, leſt the matter, when it grows ſtiff, ſhould adhere too cloſely to the veſſel. When all the humidity is evaporated, you will have a Salt of a darkiſh colour, and alkaline nature; which you may melt in a crucible, and mould into cakes. This is the Fixed Salt of plants, prepared in the manner of Tachenius.

OBSERVATIONS.

The Fixed Salt obtained from plants in the manner invented by Tachenius, and here deſcribed, is in many reſpects different from the Cauſtic Fixed Alkali extracted out of the aſhes of plants that have been conſumed by flaming in the open air. Tachenius's Salt is indeed of an Alkaline nature; but much weaker than a pure Fixed Alkali. It is not by far ſo cauſtic; it attracts the moiſture of the air much more feebly and ſlowly; it melts with a much ſmaller degree of heat; and it doth not make ſo ſtrong an effervescence with Acids. In ſhort, if you diſſolve it in water, evaporate the ſolution to a pellicle, and ſet it in a cool place, it will ſhoot into ſmall cryſtals; which is not the caſe with a pure Fixed Alkali.

Theſe ſeveral different effects, which characterize Tachenius's Salt, and diſtinguiſh it from the Cauſtic Fixed Alkali produced by burning a plant in the open air, prove that it is not a pure Alkali, but combined with certain ſubſtances that bring it nearer to the nature of a Neutral Salt, and place it, as it were, in the mid-way between ſuch a Salt and a true Alkali. If we reflect on the manner in which it is produced, it is eaſy to perceive what thoſe ſubſtances are that muſt be combined with it. It hath been ſhewn that plants, when analyzed, yield a great deal of Oil and of Acid. When they are burnt in the open air, all their Oil is diſſipated in ſmoke, or conſumed in flame. Great part of the Acid is likewiſe diſſipated, and the remainder combining with the Earth of the plant forms a Fixed Alkali.

When the ſame plants are analyzed, by diſtilling them in cloſe veſſels, the ſame principles are carried up by the action of the fire, forced to ſeparate from the fixed parts, and paſs over into the receiver in the form of vapours and of a liquid: but, when they are burnt in the manner of Tachenius, the Acid and Oil of the plant, as faſt as they are expelled by the action of the fire, are repelled by the iron cover, which, at the ſame time that it prevents the Oil from being entirely conſumed in flame, obliges theſe two ſubſtances to circulate, reverberates them on the reſt of the plant, and, in a manner, forces them to re-unite, in part, with that from which they were juſt before ſeparated.

A conſiderable quantity, therefore, of the Oil and Acid of the plant, muſt evidently combine, in this operation, with its Fixed Salt, as faſt as it is produced; and the properties above ſpecified are owing to theſe two ſubſtances. Tachenius's Salt is, therefore, a Fixed Alkali, partly neutralized by ſome of the Acid of the plant, and rendered a little ſaponaceous by a portion of its Oil; whence it is much milder than a pure Fixed Alkali, and proper to be given internally, as an excellent remedy in ſeveral diſorders.

For the medicinal virtues of this Salt Mr. Boerhaave's Chymiſtry ought to be conſulted, as the author was a very good judge of ſuch matters.

Tachenius's Salt may be converted into a Cauſtic Fixed Alkali, by freeing it from the Acid and from the Oil to which its peculiar properties are owing. For this purpoſe nothing more is requiſite than to calcine it for a long time in a crucible, ſtirring it frequently with an iron wire, and taking care not to melt it, till it have undergone the ſame changes, and ſucceſſively acquired the ſame colours, as our Fixed Alkali; and, when it becomes reddiſh, melting it and keeping it in fuſion for an hour or two.

Hitherto no ſenſible difference hath been obſerved between the Cauſtic Fixed Alkalis obtained from different plants, when equally calcined; except that thoſe produced by Sea-plants have, as we ſaid before, the ſame properties as the Alkaline baſis of Sea-ſalt. Much the ſame thing may be ſaid of the Fixed Salts obtained from plants by Tachenius's method: for, though they be combined with a portion of the Acid and Oil of the plant, yet, as theſe principles have been expoſed to the action of a ſtrong fire, they are exceedingly altered, and almoſt wholly reduced to one and the ſame condition.

PROCESS III.

To render Fixed Alkalis very cauſtic by means of Lime. The Cauſtic Stone.

TAKE a lump of newly burnt quick-lime, that hath not yet begun to ſlake in the air: put it into a ſtone pan, and cover it with twice its weight of the unwaſhed aſhes of ſome plant, that are full of the Salt you deſign to render cauſtic. Pour on them a great quantity of hot water; let them ſteep in it five or ſix hours, and then boil them gently. Filter the liquor through a thick canvas bag, or through brown filtering paper ſupported by a linen cloth.

Evaporate the filtered liquor in a copper baſon ſet over the fire; and there will remain a Salt, which muſt be put into a crucible ſet in the fire. It will melt, and boil for ſome time; after which it will be ſtill, and look like an Oil, or melted Fat. When it comes to this condition, pour it out on a very hot copper plate, and cut it into oblong tapering ſlips, before it grow hard by cooling. Put theſe ſlips, while they are ſtill hot, into a very dry glaſs bottle, and ſeal it hermetically. This is the *Cauſtic Stone*, or *common Cauſtic*.

OBSERVATIONS.

THE deſign of this operation is to combine with the Fixed Alkali all the ſaline acrid parts of the quick-lime. This is to be effected only by diſperſing and diffuſing both thoſe ſubſtances in water, which is the proper ſolvent of all ſaline matters. Seeing, therefore, we muſt have an actual lixivium, it is needleſs to employ an Alkali already prepared and ſeparated from aſhes; for which reaſon we directed aſhes that are ſtill replete with Alkali to be uſed inſtead of a pure Alkali. By this means two ends are anſwered at once: the Salt contained in the aſhes is extracted from them, and combined with the moſt acrid, ſubtile, and ſaline parts of the lime.

The lye, when ſaturated with theſe two ſaline matters together, is vaſtly more acrid and cauſtic than if it contained but one of the two in a quantity equal to both. With this lye Soap is uſually made; becauſe the acuated Alkali contained in it hath a much greater effect on Oils than any other kind of Alkali. It alſo acts with incredible violence on all animal matters; which it diſſolves, divides, and, in ſome meaſure, deſtroys, with ſurpriſing efficacy and quickneſs.

For this reaſon it is impoſſible to filter it through a woollen or ſilken bag; for it will eat holes in them, or even reduce them to a pap, almoſt as ſoon as it touches them. Beſides, as the lye would diſſolve ſome part thereof, it would thence acquire a ſaponaceous quality, and ſo loſe much of its cauſtic nature. We muſt, therefore, neceſſarily uſe a filter made of vegetable matters, which reſiſt this deſtroying Salt much better than animal matters.

An Alkali thus acuated by quick-lime attracts and retains humidity more ſtrongly than ony other kind of Alkali, even the perfecteſt and beſt calcined. For this reaſon it is almoſt impoſſible to dry it thoroughly in the baſon wherein you evaporate the lixivium.

To the moiſture ſtill left in it muſt be attributed its boiling when it begins to melt in the crucible. When all the humidity is diſſipated, the fuſed Salt remains ſmooth and unruffled, like wax melted with a gentle heat.

This cauſtic Salt is vaſtly more fuſible than the common Alkalis. It ſcarce grows red before it flows like wax. When it is once in quiet fuſion, all the humidity that occaſioned the boiling obſerved at firſt being diſſipated, it is as cauſtic as it can be made. It is then time to pour it out, and to cut it into long narrow ſticks, fit for the uſe of Surgeons, who apply it to eat away calloſities and excreſcences, and to open iſſues. On this account it is called the *Cauſtic Stone*. The operation of this Salt is ſo quick, that, in a very ſhort time, it produces on the ſkin a ſenſation like that of fire.

As this Salt grows ſurpriſingly ſoon moiſt in the air, and loſes its virtue when ſo moiſtened, it is neceſſary to ſhut it up, while it is ſtill hot, in a very dry bottle, which muſt be immediately ſtopped with a glaſs ſtopple rubbed with emery, or elſe with a ſound cork and then dipt in pitch. In ſpite of all theſe precautions, it can ſcarce be kept five or ſix months in full vigour; eſpecially if the bottle be ſometimes opened in the mean while. We ſhall not attempt to explain here why an Alkali becomes ſo violently cauſtic by being combined with quick-lime. This queſtion ſeems to be one of the moſt ſubtile, and the moſt difficult to anſwer, in all Chymiſtry. It depends on the cauſe of the Alkaline properties of lime; and can hardly be reſolved, till we attain a further inſight into the nature of that ſubſtance than we have yet got.

PROCESS IV.

The Analyſis of Soot.

TAKE wood-ſoot from a chimney under which no animal matter hath been dreſſed or burnt: put it into a glaſs retort ſet in a reverberating furnace; lute on a receiver, and begin to diſtil with a degree of heat ſomewhat leſs than that of boiling water. A conſiderable quantity of limpid phlegm will come over. Keep the fire in the ſame degree as long as any of this phlegm riſes; but increaſe it when the drops begin to come ſlow: and then there will aſcend a good deal of a milky water. When this water ceaſes to run, change the receiver, and increaſe your fire a little: a yellow Volatile Salt will riſe, and ſtick to the ſides of the receiver. The fire ought now to be very fierce, and, if ſo, will force up at the ſame time a very thick black Oil. Let the veſſels cool: you will find a ſaline matter riſen into the neck of the retort, which could not paſs over into the receiver: in the bottom of the retort will be a *caput mortuum*, or black charred ſubſtance, the upper part of which will be cruſted over with a ſaline matter, like that in the neck of the retort.

OBSERVATIONS.

THE preceding analyſis ſhewed what principles are obtained from vegetable ſubſtances without the aid of fire; thoſe which the heat of fire raiſes and carries over out of one cloſe veſſel into another; and, laſtly, thoſe that continue fixed after the vegetable hath been thoroughly charred, either in a cloſe veſſel, or in the open air: nothing therefore remained, to finiſh the ſubject of vegetable principles, but to examine thoſe which fire raiſes, in the form of vapours, ſmoke, and flame, from a vegetable matter burnt and conſumed in the open air. Every body knows that Soot conſiſts only of theſe principles, collected in the ſhafts of chimneys, which ſerve as alembics for this ſort of diſtillation in the open air. By analyſing Wood-ſoot, therefore, we ſhall diſcover the principles we are in queſt of. The proceſs we have given for that purpoſe is taken from Boerhaave's Chymiſtry, where we find it deſcribed with great exactneſs and preciſion.

As we are at preſent inquiring into the nature of vegetables only, it is evidently neceſſary that we chuſe a Soot produced by burning vegetables alone. Soot, though dry in appearance, contains nevertheleſs much humidity, as appears from this analyſis; ſeeing there comes over at firſt a conſiderable quantity of phlegm, that doth not ſeem to be impregnated with any principle, except perhaps an extremely ſubtile, ſaline, and oily matter, that communicates to it a diſagreeable ſmell, from which it cannot by any means be entirely freed.

The white milky liquor, which follows this firſt phlegm, is ſtill water, but much more impregnated with ſaline and oily parts than the former. By its ſmell, which is exceeding quick and pungent, we may judge it contains much Volatile Alkali; and accordingly, when re-diſtilled by itſelf, it yields a Volatile Spirit, and a Volatile Salt in a concrete form. With regard to its white colour, it is occaſioned by the oily parts which are diffuſed and ſuſpended, but not diſſolved, in the water. When this ſecond liquor is come off, there aſcends a Volatile Alkali in a dry form, and a very thick black Oil; becauſe there is not moiſture enough left to diſſolve theſe principles, or rather to divide and diſperſe them.

The Volatile Alkali obtained from Soot is, in a double reſpect, the product of the fire. In the firſt place, though it derives its origin wholly from wood, or other vegetables, which, when diſtilled in cloſe veſſels, yield no Volatile Alkali at all, yet it produces ſuch a Salt when analyzed in the preſent manner: whence it muſt be inferred, that the principles of thoſe vegetables are metamorphoſed into a Volatile Alkali, by being burnt in the open air, and ſublimed in the form of Soot. Secondly, though Soot when analyzed yields a great deal of this Salt, yet this Salt doth not formally preexiſt therein; for it doth not riſe till after the phlegm, nor without a very conſiderable degree of heat: therefore Soot contains only the materials neceſſary to form this Salt; therefore the perfect combination of this Salt requires that the force of fire be applied a ſecond time; therefore it is, as was ſaid, doubly the product of the fire.

The ſaline matter which we find ſublimed into the neck of the retort, and which alſo forms the cruſt that covers the *caput mortuum* of the Soot, appears by all Chymical trials to be an Ammoniacal Salt; that is, a Neutral Salt conſiſting of an Acid and a Volatile Alkali. This Ammoniacal Salt riſes only into the neck of the retort, and doth not come over into the receiver: becauſe it is but ſemi-volatile. We ſhall treat more at large of the production of a Volatile Alkali, and of this Ammoniacal Salt, when we come to the analyſis of Animals, and the article of Sal Ammoniac.

The charred matter that remains in the retort after diſtillation, being burnt in the open air, is reduced to an exceeding fixed white earth. As this fixed matter was part of that very Soot, which was ſublimed to a great height whilſt the vegetable was burning; this is a proof of what we advanced before, that the moſt fixed matters are capable of ſublimation, when united with volatile ſubſtances; eſpecially when they are expoſed at the ſame time to the combined action of air and of fire.

CHAP. VIII.

The ANALYSIS *of ſome particular* SUBSTANCES *belonging to the* VEGETABLE KINGDOM.

PROCESS I.

Analyſis of the natural Balſams: inſtanced in Turpentine.

INTO a cucurbit put as much rain-water as will fill about a fourth part of its cavity, and pour into it the Turpentine you intend to analyze. Cover the cucurbit with its head, and lute it on with ſlips of ſized paper or wet bladder. Set your alembic in a ſand-heat; lute on a long-necked receiver; and give a gradual fire till the water in the cucurbit boil. There will come over into the receiver a good deal of phlegm, which, by little and little, will become more and more acid; and at the ſame time there will riſe a great quantity of an æthereal Oil, extremely light, fluid, and as limpid and colourleſs as water.

When you obſerve that no more Oil comes off, unlute your veſſels; and in the receiver you will find an acidulated water, and the æthereal Oil floating on it. Theſe two liquors may be eaſily ſeparated from each other, by means of a glaſs funnel.

In the cucurbit will be left ſome of the water you put in, together with the remainder of your turpentine; which, when cold, inſtead of being fluid as it was before diſtillation, will be ſolid, and of the conſiſtence of a reſin, and is then called *Roſin*.

Put this reſiduum into a glaſs retort, and diſtil it in a reverberatory with a naked fire, gradually increaſed according to the general rule for all diſtillations. At firſt, with a degree of heat a little greater than that of boiling water, you will ſee two liquors come over into the recipient; one of which will be aqueous and acid, the other will be a tranſparent, limpid, yellowiſh Oil, floating on the acid liquor.

Continue your diſtillation, increaſing your fire from time to time, by ſlow degrees. Theſe two liquors will continue to come off together: and the nearer the operation draws to its end, the more acid will the aqueous liquor become, and the thicker and deeper coloured will the Oil grow. At laſt the Oil will be very thick, and of a deep reddiſh-yellow colour. When nothing more aſcends, unlute your veſſels: in the retort you will find only a very ſmall quantity of a charred, light, friable ſubſtance.

OBSERVATIONS.

ALL Natural Balſams, as well as Turpentine, are oily, aromatic matters, which flow in great quantities from the trees containing them, either ſpontaneouſly, or through inciſions made on purpoſe. As theſe matters have a ſtrong ſcent, it is not ſurpriſing that they ſhould greatly abound with Eſſential Oils. They may even be conſidered as Eſſential Oils, that naturally, and of their own accord, ſeparate from the vegetables in which they exiſt.

Indeed theſe Natural Balſams differ from the Eſſential Oils obtained out of plants by diſtillation, in this alone, that the former contain a greater proportion of Acid; and, for that reaſon, are thicker than Eſſential Oils diſtilled with the heat of boiling water. But it hath been ſhewn, that theſe ſame diſtilled Eſſential Oils, though ever ſo fluid and light at firſt, gradually loſe their tenuity as they grow old, and at laſt become conſiderably thick. On that occaſion we obſerved that they are thus changed, becauſe the lighteſt, moſt fluid, and leaſt acid parts, are little by little diſſipated and evaporated; ſo that at laſt there remains only the thickeſt and heavieſt part, which owes theſe qualities to the Acid wherewith it is over-doſed.

Hence it follows, that Natural Balſams, and Eſſential Oils grown thick with age, are exactly one and the ſame thing. Accordingly we ſee that fire and diſtillation produce the ſame effects on both. The rectification of an Eſſential Oil, thickened by keeping, is nothing but a decompoſition thereof, by ſeparating, with the heat of boiling water, all thoſe parts that are light enough to riſe with that degree of heat, from what is ſo loaded with Acid as to remain fixed therein.

This operation is therefore preciſely the ſame as our firſt diſtillation of Balſams with the heat of boiling water, by which the Eſſential Oil contained in them is drawn off. The reſidues of theſe two operations are alſo the ſame: each of them is a thick Oil, loaded with Acid, that is wholly, or nearly, deprived of the principle of odour peculiar to the original vegetable, and requires a degree of heat greater than that of boiling water to decompoſe it, by ſeparating part of the Acid from the Oil; which will be rendered ſtill the more fluid, the more the thickening Acid is ſeparated from it by repeated diſtillations.

The newer Natural Balſams are, the thinner they are, and the more Eſſential Oil do they yield; and this Eſſential Oil, like all others, grows thick in time, and at laſt turns again to an actual Balſam.

Theſe Balſams, by being long expoſed to the heat of the ſun, acquire ſuch a conſiſtence as to become ſolid. They then take another name, and are called *Reſins*. Reſins yield much leſs Eſſential Oil, when diſtilled, than Balſams do. Hence it follows, that Reſins are to Balſams, what Balſams are to Eſſential Oils. All theſe effects are produced by the cauſes aſſigned above, and confirm the analogy we have eſtabliſhed.

We have no other obſervations to make on this analyſis of Turpentine, except that when Roſin is diſtilled in a retort with a naked fire, the operation muſt be carried on very ſlowly, and the fire duly governed: for the matter is apt to ſwell, and to riſe in ſubſtance into the receiver, without being at all decompoſed. In order to avoid this inconvenience, it is adviſeable to make uſe of a long-bodied retort, ſuch as is known by the name of the *Engliſh Retort*.

If you ſtop the diſtillation of Roſin about mid-way, or when the Oil that comes over begins to grow thick, you may, by changing the receiver, keep the firſt Oil apart: it is pretty fluid, and of a middle nature between the æthereal Oil, obtained with the heat of boiling water, and the laſt thick Oil, that doth not riſe till towards the end of the diſtillation. This laſt thick Oil is that which Mr. Homberg fired with concentrated Oil of Vitriol.

If we examine the matter contained in the retort, when the diſtillation is thus ſtopped ſhort, it appears, when cold, in the form of a ſolid ſubſtance, almoſt perfectly diaphanous, of a deep reddiſh-yellow colour, and friable: It is known by the name of *Colophony*.

This analyſis of boiled Turpentine, is a ſpecimen of the analyſis of almoſt all other reſins; ſo that what hath been ſaid on this occaſion is in a manner general, and applicable to other decompoſitions of the ſame kind. We ſhall now proceed to examine ſome other oily matters, which exhibit peculiar phenomena, and do not come under the general rules.

PROCESS II.

The Analyſis of Reſins: inſtanced in Benjamin: The Flowers and Oil of Benjamin.

INTO a pretty deep earthen pot, having a border or rim round its mouth, put the Benjamin you intend to analyze. Cover the pot with a large conical cap of very thick white paper, and tye it on under the rim. Set your pot in a ſand-bath, and warm it gently till the Benjamin melt. Continue the heat in this degree for an hour and half. Then untie the paper cap and take it off, ſhaking it as little as poſſible. You will find all the inſide of the cap covered with a great quantity of beautiful, white, ſhining Flowers, in the form of little needles. Bruſh them off gently with a feather, put them into a bottle, and ſtop it cloſe.

As ſoon as you take off the firſt cap, cover your pot immediately with a ſecond like the former. In this manner go on till you perceive the Flowers begin to grow yellowiſh; and then it is proper to deſiſt.

The matter left in the pot will be blackiſh and friable when cold. Pulverize it; mix it with ſand; and diſtil it in a glaſs retort with a graduated heat. There will come over a light Oil, of a fragrant ſcent, but in very ſmall quantity; a little of an acid liquor, and a great quantity of a red thick Oil. There will be left in the retort a charred, ſpongy ſubſtance.

OBSERVATIONS.

ALL oily matters, that are naturally thick and in a concrete form, reſemble each other in this, that they derive theſe qualities from an Acid combined with them. But they nevertheleſs differ greatly from one another in many reſpects. The quality, the quantity, of the Acid to which they owe their conſiſtence, and the manner in which it is united with them, diverſify them a thouſand ways.

In the preceding proceſs we advanced, that Natural Balſams are diſtinguiſhed from Reſins by their containing ſo much more Oil, in proportion to their Acid, as ſuffices to render them almoſt fluid. For this reaſon they yield an Eſſential Oil: whereas Reſins, on the contrary, are ſolid; all their Oil being loaded and weighed down with a great quantity of Acid, ſo that no Eſſential Oil can be drawn from them.

We obſerved at the ſame time, that, when all the Eſſential Oil contained in a Natural Balſam is drawn off, with the heat of boiling water, the reſidue takes a ſolid conſiſtence, and reſembles a Reſin. In fact, almoſt all Reſins yield, by diſtillation, the ſame principles as that reſidue; that is, an Oil of a middling nature between Eſſential Oils and thick Oils, in point of lightneſs and fluidity; the whole being always accompanied with an Acid diffuſed in phlegm.

In conſequence hereof, the analyſis of Benjamin, deſcribed in the proceſs, appears to vary much from that of other Reſins: for here we ſee a volatile matter in a concrete form; namely, the white Flowers that riſe firſt; which doth not uſually occur in the analyſis of Reſins. Yet, if we examine the matter, we ſhall be convinced that it is very analagous to one of the principles obtainable from all Reſins; that indeed it differs therefrom in ſome of its properties, particularly in its external form; but that it is in reality the very ſame.

In fact, the Flowers of Benjamin are no other than an Oily Acid, nearly of the ſame nature with thoſe obtained from all other vegetable ſubſtances; but which, inſtead of being liquid like them, appears in a dry concrete form, and in a manner cryſtallized. It probably derives this property from its Oil being combined with its Acid, either in greater quantity, or in a more intimate manner, than in the reſt, and ſo ſtrongly united therewith as not to be ſeparated from it by a ſubliming heat; or from hence, that the compound, of which it is a part, contains too little phlegm to diſſolve it; or elſe, that it is hindered from diſſolving therein by the Oil with which it is combined. Perhaps all theſe cauſes may concur together in producing its concrete form.

The ſaline character of this ſubſtance appears chiefly from its being ſoluble in water: but the water muſt be very hot, and even boiling, before it will effect this ſolution; and when it cools, the Salt ſhoots into fine needles at the bottom. This phenomenon directs us to a method of ſeparating it from Benjamin without ſublimation.

For this purpoſe the Reſin muſt be boiled in water: the water will then diſſolve the Salt; and, as it cools, the Salt will cryſtallize, and may be eaſily collected. But as the Oil, with which the Acid is combined, hinders the water from diſſolving it ſo eaſily as it otherwiſe would, we cannot obtain quite ſo much of it, from the ſame quantity of Benjamin, by decoction as by ſublimation; the laſt portions thereof being united with a great quantity of Oil, which defends them againſt the action of the water. This Salt diſſolves readily in Spirit of Wine, on account of the Oil combined with it. A courſe of well connected experiments might give us a far greater inſight into its natural properties than we can now boaſt of.

Benjamin yields a much ſmaller quantity of fluid Oil by diſtillation than other Reſins do; becauſe the greateſt part of its Oil is employed in the compoſition of its oily, volatile, acid Salt. The thick Oil drawn from this Reſin, is thicker than that obtained from any other Reſin, and even fixes like butter when cold; nor can we get more than a very ſmall quantity of Acid in a diſtinct liquor. All theſe effects depend on what we mentioned above, in relation to its ſaline flowers: to wit, the peculiar and intimate union between the Acid and Oily part of this Reſin, ſo that the fire cannot ſo eaſily or ſo perfectly disjoin them, as it doth thoſe of other Reſins.

Benjamin, when diſtilled, leaves in the retort much more of a charred coal than is left by moſt other reſinous matters. This may be owing to the conſiderable quantity of earthy matter which it contains, and which, perhaps, may alſo be one of the cauſes that contribute to give its Salt a concrete form.

REFLECTIONS

On the Nature and Properties of CAMPHOR.

WE do not propoſe to give an analyſis of this ſingular body; becauſe hitherto there is no proceſs known in Chymiſtry by which it can be decompoſed. We ſhall therefore content ourſelves with reciting its principal properties, and making a few reflections on its nature.

Camphor is an oily concrete ſubſtance; a kind of Reſin, brought to us from the iſland of Borneo, but chiefly from Japan. This ſubſtance reſembles Reſins, in being inflammable, and burning much as they do; it is not ſoluble in water, but diſſolves entirely and perfectly in Spirit of Wine; it is eaſily ſeparated again from this menſtruum, as all other oily matters are, by the addition of water; it diſſolves both in expreſſed and in diſtilled Oils; it hath a very ſtrong aromatic ſmell. Theſe are the chief properties which Camphor poſſeſſes in common with Reſins: but in other reſpects it differs totally from them; eſpecially in the following particulars.

Camphor takes fire and flames with vaſtly more eaſe than any other Reſin. It is ſo very volatile, that it vaniſhes entirely in the air, without any other heat than that of the atmoſphere. In diſtillation it riſes entire, without any decompoſition, or even the leaſt alteration. It diſſolves in concentrated mineral Acids; but with circumſtances very different from thoſe that attend other oily or reſinous ſubſtances. The diſſolution is accompanied with no effervеſcence, no ſenſible heat; and conſequently can produce no inflammation. Acids do not burn, blacken, or thicken it, as they do other oily matters; on the contrary, it becomes fluid, and runs with them into a liquor that looks like Oil.

Camphor doth not, like other oily matters, acquire a diſpoſition to diſſolve in water by the union it contracts with Acids; though its union with them ſeems to be more intimate than that of many oily matters with the ſame Acids. On the contrary, if a combination of Camphor and an Acid be diluted with water, theſe two ſubſtances inſtantly ſeparate from each other: the Acid unites with the water, and the Camphor, being entirely diſengaged from it, ſwims on the ſurface of the liquor. Neither Volatile Alkalis, nor the moſt cauſtic Fixed Alkalis, can be brought into union with it; for it always eludes their power.

Notwithſtanding theſe wide differences between Camphor and all other oily and reſinous ſubſtances, the rule, that Acids thicken Oils, ſeems to be univerſal, and ſo conſtantly obſerved by nature, that we cannot help thinking this ſubſtance, like all the reſt, is an Oil thickened by an Acid. But what Oil? What Acid? and how are they united? This is a ſubject for very curious inquiries.

With a yellow Oil drawn from wine, and an acid vinous Spirit, of which we ſhall ſay more under the article of Æther, Mr. Hellot made a kind of artificial Camphor; a ſubſtance having the odour, ſavour, and inflammability of Camphor; an imperfect Camphor. True Camphor hath the levity, the volatility, and the inflammability of Æther. Can it be a ſubſtance of the ſame nature with Æther, a kind of ſolid Æther, an Æther in a concrete form?

PROCESS III.

The Analyſis of Bitumens: inſtanced in Amber. The Volatile Salt and Oil of Amber.

INTO a glaſs retort put ſome ſmall bits of Amber, ſo as to fill but two thirds of the veſſel. Set your retort in a furnace covered with its dome; fit on a large glaſs receiver; and, beginning with a very gentle heat, diſtil with degrees of fire. Some phlegm will firſt come off, which will gradually grow more acid, and be ſucceeded by a Volatile Salt, figured like fine needles, that will ſtick to the ſides of the receiver.

Keep the fire up to this degree, in order to drive over all the Salt. When you perceive that little or none riſes, change the receiver, and increaſe your fire a little. A light, clear, limpid Oil will aſcend. As the diſtillation advances, this Oil will grow higher coloured, leſs limpid, and thicker, till at laſt it will be opaque, black, and have the conſiſtence of Turpentine.

When you perceive that nothing more comes off, though the retort be red-hot, let the fire go out. You will have in the retort a black, light, ſpongy coal. If you have taken care to ſhift the receiver, from time to time, during the diſtillation of your Oil, you will have ſundry ſeparate portions thereof, each of which will have a different degree of tenuity or thickneſs, according as it came over at the beginning, or towards the end of the diſtillation.

OBSERVATIONS.

THE ſubſtance of which we have here given the analyſis, together with all others of the ſame, that is, of the Bituminous kind, is by moſt Chymiſts and Naturaliſts claſſed with Minerals: and ſo far they are right, that we actually get theſe mixts, like other minerals, out of the bowels of the earth, and never procure them immediately from any vegetable or animal compound. Yet we have our reaſons for proceeding otherwiſe, and for thinking that we could not, in this work, place them better, than immediately after thoſe vegetable ſubſtances which we call Reſins.

Several motives determine us to act in this manner. The analyſis of Bitumens demonſtrates, that, with regard to the principles of which they conſiſt, they are totally different from every other kind of mineral; and that, on the contrary, they greatly reſemble vegetable Reſins in almoſt every reſpect. In ſhort, though they are not immediately procured from vegetables, there is the greateſt reaſon for believing that they were originally of the vegetable kingdom, and that they are no other than reſinous and oily parts of trees or plants, which, by lying long in the earth, and there contracting an union with the mineral Acids, have acquired the qualities that diſtinguiſh them from Reſins.

Mineralogiſts know very well that we find, every where in the earth, many vegetable ſubſtances, that have lain very long-buried under it, and frequently at a conſiderable depth. It is not uncommon to find, under ground, vaſt beds of foſſile trees, which ſeem to be the remains of immenſe foreſts: and Bitumens, particularly Amber, are often found among this ſubterraneous wood.

Theſe conſiderations, joined to proofs drawn from their analyſis, make this opinion more than probable: nor are we ſingular in maintaining it, as it is adopted by many able modern Chymiſts.

The analyſis of Amber, above deſcribed, may ſerve as a general ſpecimen of the decompoſition of other Bitumens: with this ſingle difference, that Amber is the only one among them which yields the Volatile Salt aforeſaid; and this determined us to examine it preferably to any other. As for the reſt, they all yield a phlegm, an acid liquor, and an Oil; which is thin at firſt, but grows thicker and thicker, as the diſtillation draws towards an end. It muſt be underſtood, however, that theſe Acids and theſe Oils may differ, according to the nature of the Bitumens from which they are drawn; juſt as the Phlegm, the Acid, and the Oil, reſulting from the decompoſition of Reſins, differ in quantity and quality, according to the nature of the Reſins from which they are procured.

The principal differences obſerved between Reſins and Bitumens are theſe: the latter are leſs ſoluble in Spirit of Wine; have a peculiar ſcent, which cannot be accurately deſcribed, and of which the ſenſe of ſmelling only can judge; and their Acid is ſtronger and more fixed. This laſt property is one of the motives which induce us to think, that, beſides the vegetable Acid, originally combined with the reſinous or oily matter now become a Bitumen, a certain quantity of mineral Acid hath, in a courſe of time, been ſuperadded to conſtitute this mixt. We ſhall preſently ſee that the fact is certainly ſo, in the caſe of Amber at leaſt.

Almoſt all authors, who mention the analyſis of Amber, have given different accounts of the volatility of its Salt, and of the time of the diſtillation when it begins to riſe. Some make it aſcend immediately after the firſt acid phlegm. Others ſay, that it doth not begin to appear till after the firſt thin Oil; and others again affirm, that it comes over with the laſt thick Oil. Mr. Bourdelin, who hath examined this matter to the bottom, in a Memoir on the analyſis of Amber given in to the Academy, very judiciouſly remarks, that the different reſults which thoſe Chymiſts met with in analyzing our mixt, aroſe wholly from the different manner wherein each conducted his fire during the operation.

It is certain that ſuch a cauſe is capable of producing vaſt differences: for when fire is haſtily applied, or made too violent, it not only confounds and tumultuouſly mingles the principles of the body to be analyzed, but it even frequently drives up the entire ſubſtance itſelf out of the retort into the receiver, without decompoſing it at all. This is really ſo in the caſe of Amber, and of almoſt all compound ſubſtances that are not extremely fixed.

It ought therefore to be obſerved, as a general and important rule in every analyſis, to adminiſter the fire exceeding ſlowly and cautiouſly, as one can never err on that ſide; and to increaſe it only by ſuch degrees as appear neceſſary for carrying on the diſtillation. By obſerving this method, an accurate analyſis will be attained: by this means the Salt of Amber will riſe before the Oil; whereas, if a degree of heat ſufficient to raiſe the thin Oil, or even the thick Oil, be applied at firſt, the Salt will accordingly come over with the one or the other of theſe Oils.

Chymiſts remained a long time unacquainted with the nature of this Salt of Amber, and authors of the greateſt fame agreed as little on this point as on that juſt mentioned. Some aſſerted it to be a Volatile Salt of the ſame kind with that which is obtained from animal ſubſtances; that is, a Volatile Alkali: others, on the contrary, pretended that it was an Acid of a ſingular nature.

It is very ſurpriſing that ſuch authors ſhould diſagree on ſuch a point, conſidering how eaſily it may be aſcertained whether this Salt be really an Acid or an Alkali. Mr. Bourdelin juſtly decides the queſtion in favour of thoſe who affirm it to be an Acid. In fact it hath all the properties of an Acid: it hath the taſte of one, forms Neutral Salts with Alkalis, and differs from the moſt unqueſtionable Acids in this alone, that, being combined with a portion of Oil and a ſmall quantity of earth, theſe give it a concrete form; which is not a ſolitary caſe in Chymiſtry, as is evident from Cream of Tartar. With regard to its Volatility, there is nothing in that repugnant to the properties of its conſtituent principles; ſeeing the Acid and the Oil predominant therein may eaſily be ſuppoſed to communicate their volatile nature to the ſmall portion of earth with which they are combined.

Thoſe Chymiſts who looked upon the Salt of Amber as a Volatile Alkali, either did not examine it thoroughly, but contented themſelves with its firſt appearance, in which it reſembles the Volatile Salt of animals, or elſe were led into the error by ſome particular circumſtances. We know, for example, that animal as well as vegetable ſubſtances are dug out of the earth. The inſects, ſometimes found incloſed in lumps of Amber, ſufficiently prove this. Perhaps they made their experiments on ſuch pieces of Amber; or elſe, that which they uſed might be mixed with ſome animal ſubſtance not very perceptible. In ſuch a caſe, it would be no wonder if the Volatile Salt obtained ſhould ſhew ſome tokens of an Alkali: for the Volatile Alkali ariſing from the animal matter would only be mixed, not combined, with the Salt of the Amber; as the great quantity of the Oil, in which both theſe Salts are entangled, would hinder them from diſſolving each other, and forming ſuch a Neutral Salt as would be produced in other circumſtances.

The acid or alkaline nature of the Salt of Amber was not the only point that remained to be diſcuſſed on this occaſion. Its acid quality being once clearly aſcertained, the nature of this Acid was next to be determined. This is the object chiefly aimed at in Mr. Bourdelin's Memoirs, and his diſcovery thereof is unqueſtionably one of the fineſt, and at the ſame time one of the moſt difficult, that could be attempted with regard to this Bitumen.

It appears plainly from ſeveral experiments, of which we have given an account in the courſe of this work, that the ſtrongeſt mineral Acids, by being combined with an oily matter, are ſo vaſtly altered, and ſo ſtrangely diſguiſed, that we not only are incapable of diſtinguiſhing what they are, but even can hardly avoid decompoſing, and partly deſtroying them, by thoſe very operations which ſeem the beſt adapted to ſeparate them from the Oil in which they are inviſcated. Mr. Bourdelin had all theſe difficulties to ſurmount, and inceſſantly met with new obſtacles in that troubleſome fatty matter, which, like an impenetrable veil, concealed from his view the Acid whoſe nature he wanted to diſcover.

But at laſt, by dint of manifold experiments, he happily gained his end. Two parts of pure Nitre, unadulterated with the leaſt particle of Sea-ſalt, and one part of Amber, pulverized and mingled together, procured him, by deflagration, a Salt partly neutral and partly alkaline; which being lixiviated, and ſet to evaporate ſpontaneouſly, there formed at the bottom a reſidue of a mucilaginous, pappy, whitiſh matter, amongſt which he could diſtinguiſh cryſtals, that were very tranſparent, regularly figured, of a cubical form, but rather oblong; ſo that they repreſented little oblong ſquares moſt exactly formed, and about half a line thick.

As theſe cryſtals perfectly reſembled, in their figure, the Neutral Salt produced by a combination of the Acid of Sea-ſalt with the alkaline baſis of Nitre; this was a proof to Mr. Bourdelin that the Acid of Amber is of the ſame kind, or rather exactly the ſame, with that of Sea-ſalt. The Nitre being alkalizated by means of the phlogiſton of the Amber, the Acid of the Bitumen, finding this Alkali a proper baſis to fix in, unites with it, and by that means is enabled to reſiſt the action of the fire, ſo as not to be carried off by it.

On the other hand, it is ſeparated from the fat matter by which it was maſked before; for by the help of this fat matter the Nitre is alkalizated. The Acid, having by this means recovered all its properties, begins to diſcover them, as hath been ſaid, by the figure it conſtantly gives to the cryſtals of the Neutral Salt which it helps to conſtitute.

Moreover, this Neutral Salt hath all the eſſential properties of Sea-ſalt. It hath its taſte; it decrepitates in the ſame manner on live coals; if Oil of Vitriol be poured on it, white vapours ariſe, which have the ſmell of Spirit of Salt, and are an actual Spirit of Salt. Laſtly, it makes a white precipitate of Mercury diſſolved in Spirit of Nitre, and a *luna cornea* of Silver diſſolved in the ſame Spirit; which laſt proofs would alone be ſufficient to eſtabliſh Mr. Bourdelin's opinion, though we had no other.

It were to be wiſhed that the experiments which Mr. Bourdelin hath made on Amber were alſo tried on other Bitumens. There is reaſon to think they would be found to contain either the Marine or the Vitriolic Acid: for though they do not yield a Volatile Salt, as Amber doth, in diſtillation, yet the Acids obtained from them are very ſtrong, and appear, as we ſaid before, to have a mineral origin. Mr. Geoffroy obſerved, that Amber, being pulverized and infuſed in hot water, parts with its Salt in the ſame manner as Benjamin does; which gives room to ſuſpect that Amber is to Bitumens what Benjamin is to Reſins.

PROCESS IV.

The Analyſis of Bees-Wax, and ſuch Oily Compounds as are analogous to it.

MELT the Wax you intend to analyze, and mix with it as much fine ſand as will make it into ſtiff paſte. Put this paſte in little bits into a retort, and diſtil as uſual, with a graduated fire, beginning with a very gentle heat. An acid phlegm will come over, and be followed by a liquor which at firſt will look like an Oil, but will ſoon congeal in the receiver, and have the appearance of a butter or greaſe. Continue the diſtillation, increaſing the fire by inſenſible degrees, till nothing more will come off. Then ſeparate the butter from the acid phlegm in the receiver, mix it with freſh ſand, and diſtil it again juſt as you did the Wax before. Some acid phlegm will ſtill come off, and an Oil will aſcend, which will not fix in the receiver, though it be ſtill thick. Continue the diſtillation, with a fire ſo governed that the drops may ſucceed each other at the diſtance of ſix or ſeven ſeconds of time. Do not increaſe it, till you perceive the drops fall more ſlowly; and then increaſe it no more than is neceſſary to make the drops follow each other as above directed. When the diſtillation is finiſhed, you will find in the receiver the Oil come wholly over, and a little acid phlegm. Separate the Oil from this liquor; and, if you deſire to have it more fluid, re-diſtil it a third time in the ſame manner.

OBSERVATIONS.

BEES-WAX, like all other oily matters in a concrete form, is an Oil thickened by an Acid. Its decompoſition furniſhes us with a very convincing proof of this truth; which, you ſee, is confirmed more and more, by every new analyſis we make of ſuch ſubſtances.

Wax doth not part with all its Acid in the firſt diſtillation: and this is the reaſon that it doth not then become a fluid Oil, but a butter, which hath only a degree of ſoftneſs proportioned to the quantity of Acid ſeparated from it. The ſame thing holds with regard to its butter; which loſing, by a ſecond diſtillation, a great part of the remaining Acid which cauſed its conſiſtence, is by that means turned to an Oil. Laſtly, this Oil, from being thick, becomes very fluid by a third diſtillation, and ſo follows the general rule of Oils; which always become the more fluid the oftener they are diſtilled or rectified.

What is here ſaid concerning Wax is applicable to Reſins alſo; which it further reſembles in its conſiſtence, and its refuſing to diſſolve in water: yet it differs from them eſſentially in ſeveral reſpects; and for this reaſon we thought proper to treat of it in particular. The properties in which it differs from Reſins are theſe:

Firſt, It hath no aromatic ſcent, nor acrid taſte, as Reſins have.

Secondly, It doth not yield a thin limpid Oil, in the firſt diſtillation, as they do.

Thirdly, Its Oil, or its butter, doth not grow ſenſibly thicker with age. Mr. Boerhaave kept ſome butter of Bees-Wax for twenty years, in a veſſel that was not ſtopt, but only covered with a bit of paper; yet it did not grow hard. An Eſſential Oil, though kept much cloſer ſhut up, would in much leſs time have acquired the conſiſtence of a Balſam; and a Balſam, in that time, would have become a Reſin.

Fourthly, Bees-Wax is not ſoluble in Spirit of Wine; whereas it is the very nature of Reſins to diſſolve in that menſtruum.

Fifthly, I have obſerved that Spirit of Wine acts faintly on the butter of Bees-Wax; diſſolves that butter when diſtilled to an Oil; unites more readily with that Oil when rectified by a third diſtillation; and diſſolves it ſtill the more readily the oftener it is diſtilled. Reſins, on the contrary, are more ſoluble in Spirit of Wine than the thin Oils drawn from them; and thoſe Oils acquire the property of reſiſting that menſtruum more and more obſtinately the oftener they are rectified.

By theſe differences we may judge whether it be proper to confound Bees-Wax with Reſins, or whether it ought not rather to be conſidered as an oily compound of a ſingular ſpecies, which deſerves to be ranked in a different claſs, or at leaſt in ſome other diviſion.

If we take the moſt curſory view of the properties of Eſſential Oils, and compare them with thoſe of Fat Oils, we cannot avoid being ſtruck with a reſemblance between the properties of Eſſential Oils and thoſe of Reſins, as well as with the apparent conformity between the properties of Fat Oils and thoſe of Bees-Wax: from all which we may conclude with good reaſon, in my opinion, that the Oil of Bees-Wax is not of the ſame nature with that of Reſins. The Oil of Reſins hath all the properties of an Eſſential Oil, and is juſtly allowed to be an Eſſential Oil rendered thick and ponderous by an Acid. The Oil of Bees-Wax, on the contrary, hath all the properties of Fat Oils; and there is great room to think, that this ſubſtance is really no other than a Fat Oil hardened by an Acid.

Bees-Wax is not the only oily compound that appears to have a Fat Oil for its baſis. Certain ſhrubs in America yield, by decoction, a ſubſtance that hath all the properties of Bees-Wax, differing therefrom only in its colour, which is green. The Butter of Cacao is alſo a ſubſtance analogous to Bees-Wax, and would be really Wax, if it were but as hard; for it contains the ſame principles, but in different proportions: in ſhort, it is to Bees-Wax what Balſams are to Reſins.

PROCESS V.

The Saccharine Juices of Plants analyzed: inſtanced in Honey.

PUT into a ſtone cucurbit the Honey you intend to diſtil; ſet it in a moderate ſand-heat, and evaporate the greateſt part of its humidity, till you perceive the phlegm begin to be acid. Then take out the matter remaining in the cucurbit, put it into a retort, leaving a full third thereof empty, and diſtil in a reverberatory with degrees of fire. An acid, amber-coloured liquor will come over. As the operation advances, this liquor will continually become deeper coloured and more acid, and at the ſame time a little black Oil will aſcend. When the diſtillation is over, you will find in the retort a pretty large charred maſs, which being burnt in the open air, and lixiviated, affords a Fixed Alkali.

OBSERVATIONS.

IF we conſider nothing but the nature of the principles obtained from Honey, we may be induced to think that this ſubſtance is of the ſame kind with Reſins; for we get from each a Phlegm, an Acid, an Oil, and a Coal. Yet there is a very great difference between theſe two ſorts of compounds. Oily matters of the reſinous kind are very inflammable, and by no means ſoluble in water: Honey, on the contrary, is not inflammable in its natural ſtate; will not flame till it be half conſumed, or turned almoſt to a coal, by the fire; and mixes readily and perfectly with water. Now whence can this difference ariſe? Since it is not owing to the nature of the principles that conſtitute theſe mixts, it muſt neceſſarily be attributed to the proportions in which thoſe principles are united. And indeed if we attend to the quantities obtained from each by analyzing them ſeverally, we ſhall find that, in this reſpect, there is a very great difference between them. Oily compounds of the nature of Refins, which are not ſoluble in water, yield in diſtillation a little phlegm, a quantity of Oil vaſtly exceeding that of their Acid, and a very ſmall matter of coal, which, when burnt, ſcarce leaves any token of a Fixed Alkali. Honey, on the contrary, and all other juices of the ſame nature, give out, when analyzed, a great deal of phlegm, a quantity of Acid much ſuperior to that of their Oil, and a conſiderable maſs of coal; from which, when burnt in the open air and lixiviated, a very perceptible Alkali may be obtained.

If the quantity of the principles procured by theſe two analyſes be compared together, it will be eaſy to deduce from thence the cauſes of the different properties obſerved in the mixts that afforded them. In the large quantity of Oil, of which reſinous ſubſtances conſiſt almoſt entirely, we ſee the cauſe of their being ſo inflammable, and ſo indiſſoluble in water. When ſuch bodies are decompoſed, there remains but little coal, and very little Fixed Alkali; becauſe their Oil carries off with it almoſt all their Acid, leaving a ſcarce perceptible portion thereof fixed in the coal. Now we know that this Acid is an eſſential requiſite to the formation of an Alkali. Honey, on the contrary, and the analogous mixts, are ſo unapt to take fire, and mix ſo readily with water, only becauſe there is very little Oil in their compoſition, in compariſon of the Acid, which is their predominant principle. For the ſame reaſon they leave, when decompoſed, a greater quantity of coal, which alſo yields much more Fixed Alkali than we find in the coals of Reſins. Perhaps theſe mixts may alſo contain a little more earth. The cauſe of this greater quantity of Fixed Alkali will be found in what we delivered above concerning the combination and production of that Salt.

Sugar, Manna, and the Saccharine juices of fruits and plants, are of the ſame nature as Honey, yield the ſame principles, and in the ſame proportions. All theſe ſubſtances muſt be conſidered as native Soaps; becauſe they conſiſt of an Oil rendered miſcible with water, by means of a ſaline ſubſtance. They differ from the common artificial Soaps in ſeveral reſpects; but chiefly in this, that their ſaline part is an Acid, whereas that of common Soap is an Alkali. The natural Soaps are not for that reaſon the leſs perfect: on the contrary, they diſſolve in water without deſtroying its tranſparency, and without giving it a milky colour: which proves that Acids are not leſs proper than Alkalis, or rather that they are more proper additaments, for bringing Oils into a ſaponaceous ſtate.

But it muſt be owned, that we are not yet able to imitate by art the Acid Soaps which are prepared and ſo perfectly combined by nature, and that the deterſive quality of theſe is not near ſo ſtrong as that of the Soaps which have an Alkali for their ſaline principles.

Though Honey, and the other vegetable ſubſtances analogous to it, contain much Acid, yet they have no taſte of ſourneſs, nor any of the other properties of Acids; but, on the contrary, their taſte is ſoft and ſaccharine: the cauſe of this is, that their Acid is intimately mixed and perfectly combined with their Oil, which entirely ſheathes and blunts it.

PROCESS VI.

Gummy Subſtances analyzed: inſtanced in Gum Arabic.

DISTIL Gum Arabic in a retort with degrees of fire. A limpid, ſcentleſs, and taſteleſs phlegm will firſt come over; and then a ruſſet-coloured acid liquor, a little Volatile Alkali, and an Oil, which will firſt be thin and afterwards come thick. In the retort will be left a good deal of a charred ſubſtance, which being burnt and lixiviated will give a Fixed Alkali.

OBSERVATIONS.

GUMS have at firſt ſight ſome reſemblance of Reſins; which hath occaſioned many reſinous matters to be called Gums, though very improperly: for they are two diſtinct ſorts of ſubſtances, of natures abſolutely different from each other. It hath been ſhewn, that Reſins have an aromatic odour; that they are indiſſoluble in water, and ſoluble in

Spirit of Wine; that they are only an Eſſential Oil grown thick. Gums, on the contrary, have no odour, are ſoluble in water, indiſſoluble in Spirit of Wine, and, by being analyzed as in the proceſs, are converted almoſt wholly into a phlegm and an Acid. The ſmall portion of Oil contained in them is ſo thoroughly united with their Acid, that it diſſolves perfectly in water, and the ſolution is clear and limpid. In this reſpect Gums reſemble Honey, and the other vegetable juices analogous to it. They are all fluid originally; that is, when they begin to ooze out of their trees. At that time they perfectly reſemble mucilages, or rather they are actual mucilages, which grow thick and hard in time by the evaporation of a great part of their moiſture: juſt as Reſins are true Oils, which, loſing their moſt fluid parts by evaporation, at laſt become ſolid. Infuſions or ſlight decoctions of mucilaginous plants, when evaporated to dryneſs, become actual Gums.

Some trees abound both in Oil and in mucilage: theſe two ſubſtances often mix and flow from the tree blended together. Thus they both grow dry and hard together in one maſs, which of courſe is at the ſame time both gummy and reſinous: and accordingly ſuch mixts are named Gum-reſins.

But it muſt be obſerved, that theſe reſinous and gummy parts ſuffer no alteration by being thus mixed; but each preſerves its properties, as if it were alone. The reaſon is, that they are not truly united together: Gums being indiſſoluble by Oils or by Reſins, the parts of each are only entangled among thoſe of the other, by means of their viſcoſity. Hence, if the Gum-reſin be put into water, the water will diſſolve only the gummy part, without touching the reſinous. On the contrary, if the ſame Gum-reſin be put into Spirit of Wine, this menſtruum will diſſolve the Reſin, and leave the Gum. We ſhall treat more particularly of this diſſolution under the head of Spirit of Wine.

If a Gum-reſin, inſtead of being only infuſed in water, be triturated with water, it will be thereby wholly diffuſed through it: but the reſinous part, which is only divided by the triture, and not diſſolved in the water, gives the liquor a milky colour, like that of an emulſion. It is indeed an actual emulſion; that which is made with kernels being, like this, no other than a divided oil, diſperſed in ſmall particles by triture, and ſuſpended in the water by means of a mucilage.

SECTION

SECTION II.

Of Operations on Fermented Vegetable Subſtances.

CHAP. I.

Of the PRODUCT *of* SPIRITUOUS FERMENTATION.

PROCESS I.

To make Wine of Vegetable Subſtances that are ſuſceptible of Spirituous Fermentation.

LET a liquor ſuſceptible of, and prepared for, the Spirituous Fermentation be put into a caſk. Set this caſk in a temperately warm cellar, and cover the bung-hole with a bit of linen cloth only. In more or leſs time, according to the nature of the liquor to be fermented, and to the degree of heat in the air, the liquor will begin to ſwell, and be rarefied. There will ariſe an inteſtine motion, attended with a ſmall hiſſing and effervefcence, throwing up bubbles to the ſurface, and diſcharging vapours: while the groſs, viſcous, and thick parts, being driven up by the fermenting motion, and rendered lighter by little bubbles of air adhering to them, will riſe to the top, and there form a kind of ſoft, ſpongy cruſt, which will cover the liquor all over. The fermenting motion ſtill continuing, this cruſt will, from time to time, be lifted up and cracked by vapours making their eſcape through it; but thoſe fiſſures will preſently cloſe again, till, the fermentation gradually going off, and at laſt entirely ceaſing, the cruſt will fall in pieces to the bottom of the liquor, which will inſenſibly grow clear. Then ſtop the caſk cloſe with its bung, and ſet it in a cooler place.

OBSERVATIONS.

MATTERS that are ſuſceptible of the Spirituous Fermentation are ſeldom ſo perfectly prepared for it by nature as they require to be. If we except the juices that flow naturally from certain trees, but oftener from inciſions made on purpoſe in them, all other ſubſtances require ſome previous preparation.

Boerhaave, who hath handled this ſubject excellently well in his Chymiſtry, divides the ſubſtances that are fit for Spirituous Fermentation into five claſſes. In the firſt he places all the mealy ſeeds, the legumens, and the kernels of almoſt all fruits. The ſecond claſs includes the juices of all fruits that do not tend to putrefaction. In the third claſs ſtand the juices of all the parts of plants which tend rather to acidity than to putrefaction; and conſequently thoſe which yield much Volatile Alkali are to be excluded. The fourth claſs comprehends the juices or ſaps that ſpontaneouſly diſtil from ſeveral trees and plants, or flow from them when wounded. He forms his fifth and laſt claſs of the ſaponaceous, ſaccharine, and concrete or thick juices of vegetables. Reſinous or purely gummy matters are excluded, as not being fermentable.

Theſe five claſſes may be reduced to two; one comprehending all the Juices, and another all the Mealy parts, of vegetables that are ſuſceptible of fermentation. The juices want nothing to fit them for fermentation, but to be expreſſed out of the ſubſtances containing them, and to be diluted with a ſufficient quantity of water. If they be very thick, the beſt way is to add ſo much water as ſhall render the mixed liquor juſt capable of bearing a new-laid egg. With reſpect to farinaceous ſubſtances, as they are almoſt all either oily or mucilaginous, they require a little more management. The method of brewing malt-liquors will furniſh us with examples of ſuch management. It is thus deſcribed by Mr. Boerhaave.

In warm weather the grain is put into large vats, and a conſiderable quantity of rain-water, or very clean river-water, is poured thereon, in which it lies till it be well ſoaked and ſwelled. This firſt operation is called the *Steeping*.

When the grain is by this means grown very plump, it is taken out of the ſteep, and laid on great heaps in an open place, yet not too much expoſed to the wind. In a very little time thoſe heaps grow hot, the grain begins to ſprout, and ſhoot out little buds of leaves and roots. The art of managing this operation properly conſiſts in ſeizing the exact point of time when the germination ſhould be ſtopt: on this in a great meaſure depends the ſucceſs of the buſineſs. For, if the grain be left too long in this hot bed, it may begin to rot, or elſe the leaves and roots, by growing too much, may conſume moſt of the mealy ſubſtance, which, in this caſe, is the only ſubject of fermentation; and, if the germination be checked too ſoon, the advantage expected from it will be loſt; that is, the mucid matters will not be ſufficiently attenuated.

As ſoon therefore as the germination is obſerved to have attained its proper ſtage, it muſt be ſtopt with all poſſible expedition. For this purpoſe the grain is carried into an open place expoſed to the north wind, where it is ſpread on a boarded floor and dried; by which means it is hindered from ſprouting any more. It is next made to run ſlowly down through a long tunnel made very hot, which at once dries it thoroughly to the very heart, and in ſome meaſure ſcorches it, though very ſlightly. Grain thus prepared is called *Malt.*

By this germination, exſiccation, and ſlight torrefaction of the grain, the farinaceous ſubſtance is conſiderably attenuated, and its natural viſcoſity deſtroyed, which would otherwiſe hinder the meal, when boiled in water, from mixing with it and diſſolving in it, as it muſt in ſome meaſure do to form a liquor fit for Spirituous Fermentation.

Mr. Boerhaave takes notice, that if grain, which hath not been thus prepared, be chewed in the mouth, its meal makes a paſte that is not eaſily attenuated, or entirely diſſolved, by the ſpittle; whereas the meal of the ſame grain, after malting, mixes immediately and perfectly with the ſpittle: it hath moreover a ſweet agreeable taſte, which common grain hath not.

The grain being thus malted, is ground: then hot water is poured thereon, in which it is left to infuſe for three or four hours. In that time the water takes up all the attenuated flour of the Malt; whereas it would not diſſolve the farina of grain that had not undergone the above deſcribed preparations. The Wort is then drawn off the grains, and boiled to a proper degree of inſpiſſation; the decoction is ſuffered to cool, and afterwards put into caſks to be fermented as the proceſs directs.

As Malt-liquor is apt to grow ſour, and will not keep ſo long as Wine, ſome bitter plants are uſually boiled in the decoction, to make it keep the longer, and hinder it from turning ſour ſo ſoon as it otherwiſe would. For this purpoſe ſuch plants are choſen as have an agreeable bitter taſte; and the preference is generally given to Hops.

Beſides theſe preparations, relating chiefly to Malt-liquors, there are many other things to be obſerved relating to Spirituous Fermentation in general, and to all matters ſuſceptible of that fermentation. For example; all grains and fruits deſigned for that fermentation muſt be perfectly ripe; for otherways they will not ferment without difficulty, and will produce little or no inflammable Spirit. Such matters as are too auſtere, too acrid, or aſtringent, are for the ſame reaſon unfit for Spirituous Fermentation; as well as thoſe which abound too much in Oil.

In order to make the fermentation ſucceed perfectly, ſo as to produce the beſt Wine that the fermented liquor is capable of affording, it is neceſſary to let it ſtand quiet without ſtirring it, leſt the cruſt that forms on its ſurface ſhould be broken to little fragments, and mix with the liquor. This cruſt is a kind of cover, which hinders the ſpirituous parts from exhaling as faſt as they are formed. The free acceſs of the air is another condition neceſſary to fermentation: and for this reaſon the veſſel that contains the fermenting liquor muſt not be cloſe ſtopped; the bung-hole is only to be covered with a linen cloth, to hinder dirt and inſects from falling into it. Nor muſt the bung-hole be too large, leſt too much of the ſpirituous parts ſhould eſcape and be loſt.

Laſtly, a juſt degree of warmth is one of the conditions moſt neceſſary for fermentation: for in very cold weather there is no fermentation at all; and too much heat precipitates it in ſuch a manner, that the whole liquor becomes turbid, and many fermenting and fermented particles are diſſipated.

If, notwithſtanding the exacteſt obſervance of every particular requiſite to excite a ſucceſsful fermentation, the liquor cannot, without difficulty, be brought to effervеſce, which ſcarce ever happens but to Malt-liquor, it may be accelerated by mixing therewith ſome matter that is very ſuſceptible of fermentation, or actually fermenting. Such matters are called *Ferments*. The cruſt, or *Yeſt*, that forms on the ſurface of fermenting liquors is a moſt efficacious ferment, and on that account very much uſed.

It ſometimes happens, that there is occaſion to check the fermentation excited in the liquor, before it ceaſes of itſelf. To effect this, ſuch means muſt be uſed as are directly oppoſite to thoſe mentioned above for promoting fermentation. The end is obtained by mixing with the liquor a quantity of Alkali, ſufficient to abſorb the Acid contained therein: but this method is ſeldom made uſe of, becauſe it ſpoils the liquor: which, after being thus treated, is incapable of any ſpirituous fermentation, but on the contrary will certainly putrefy.

Spirituous fermentation may alſo be ſtopped by mixing with the liquor a great quantity of ſome mineral Acid. But this likewiſe alters its nature; becauſe theſe Acids, being fixed, always remain confounded therewith, and never ſeparate from it.

The beſt method yet found out for checking this fermentation, without injury to the fermenting liquor, is to impregnate it with the fumes of burning ſulphur. Theſe fumes are known to be acid, and it is that quality in them which ſuſpends the fermentation. But, at the ſame time, this Acid is extremely volatile: ſo that it ſeparates ſpontaneouſly from the liquor, after ſome time, and leaves it in a condition to continue its fermentation.

For this reaſon, when a Wine is deſired that ſhall be but half fermented, and ſhall partly retain the ſweet taſte it had in the ſtate of *Muſt*, (the proper name for the unfermented juice of the grape), it is put into caſks in which Sulphur hath been previouſly burnt, and the vapours thereof confined by ſtopping the bung-hole. Theſe are called *Matched Wines.* If the ſame operation be performed on Muſt, its fermentation will be abſolutely prevented: it will retain all its ſaccharine taſte, and is then called *Stum.* As the ſulphureous Acid evaporates ſpontaneouſly, in no long ſpace, it is neceſſary to fumigate matched wines, or ſtums, from time to time, when they are intended to be kept long without fermenting.

PROCESS II.

To draw an Ardent Spirit from Subſtances that have undergone the Spirituous Fermentation. The Analyſis of Wine.

FILL a large copper cucurbit half full of Wine. Fit on its head and refrigeratory. Lute on a receiver with wet bladder, and diſtil with a gentle fire; yet ſo that the drops which fall from the noſe of the alembic may ſucceed one another pretty quick, and form a ſort of ſmall continued ſtream. Go on thus till you perceive that the liquor which comes over ceaſes to be inflammable; and then deſiſt. You will find in the receiver a clear liquor, ſomewhat inclining to an amber-colour, of a pleaſant quick ſmell, and which being thrown into the fire inſtantly flames. The quantity thereof will be nearly a fourth part of the Wine you put into the alembic; and this is what is called *Brandy;* that is, the Ardent Spirit of Wine loaded with much phlegm.

In order to rectify it, and reduce it to Spirit of Wine, put it into a long-necked matraſs, capable of holding double the quantity. Fit a head to the matraſs, and lute on a receiver: place your matraſs over a pot half full of water; ſet this pot over a moderate fire; and with this vapour-bath diſtil your Spirit, which will riſe pure. Continue this degree of heat till nothing more will come over. You will find in the receiver a very clear colourleſs Spirit of Wine, of a quick but agreeable ſmell, which will catch fire at once by the bare contact of any flaming ſubſtance.

OBSERVATIONS.

IT hath been ſhewn, that Honey, and the vegetable juices analogous to it, ſuch as Muſt, and the juices of all ſaccharine fruits and plants, yield by diſtillation no other principles than Phlegm, an Acid, and a ſmall quantity of Oil. The analyſis of Wine, and of all ſubſtances that have undergone the ſpirituous fermentation, ſhews us that this fermentation produces, and in ſome ſenſe creates, in thoſe mixts, a principle that did not exiſt in them before; I mean the Ardent Spirit, which is an inflammable liquor that is miſcible with water. This liquor reſults from a cloſer combination of the Acid and the Oil, which are attenuated and united together by fermentation. To this Oil, which is one of its conſtituent parts, its inflammability is owing; and the Acid imparts to this Oil the property of mixing with water, more perfectly and more intimately than when it makes a part of any other compound. Nay, there is, in the very compoſition of an Ardent Spirit, a certain quantity of water which is neceſſary to it, which is one of its eſſential parts, and without which it would not have the properties that characteriſe it. We ſhall preſently have occaſion to ſee, that, when Spirit of Wine is dephlegmated to a certain pitch, we cannot deprive it of any more of its aqueous parts, without decompoſing a quantity of the Spirit, proportioned to the quantity of water drawn from it.

Ardent Spirits are more volatile than any of the principles of the mixt from which they are produced, and conſequently more volatile than the phlegm, the Acid, or the Oil thereof, though they wholly conſiſt of theſe. This cannot be attributed to any thing but a peculiar diſpoſition of theſe principles, which are attenuated in a ſingular manner by the fermenting motion, and thereby rendered more ſuſceptible of expanſion and rarefaction.

The great volatility of the Ardent Spirit procures us an eaſy method of ſeparating it from the other principles of Wine, and of dephlegmating it. For this purpoſe it need only be diſtilled with ſuch a gentle heat as is juſt capable of raiſing the Spirit, but too weak to produce the ſame effect on the other matters from which you deſire to free it. For this reaſon the more ſlowly, and with the leſs heat, you diſtil your Wine, the ſtronger and more ſpirituous will your Brandy be. The ſame is to be ſaid of the ſecond diſtillation, by which Brandy is changed into Spirit of Wine, or, in other words, dephlegmated. The Spirit of Wine thus drawn from it will be ſo much the better, the more exactly you obſerve the conditions here propoſed.

If Spirit of Wine be treated in the ſame manner as Brandy, that is, if it be rectified by diſtillation with the ſame precautions, it will be thereby dephlegmated as much as poſſible; and then it is called *Alkohol.* By this rectification it is not only freed from its redundant phlegm, but alſo from ſome particles of Acid and of Oil, which, though much leſs volatile than itſelf, yet aſcend with it in the firſt diſtillation: nor is it poſſible wholly to avoid this inconvenience.

Mr. Boerhaave propoſes to dephlegmate Spirit of Wine more eaſily, and more accurately, by diſtilling it from decrepitated Sea-ſalt mixed, while very hot, with the Spirit. This muſt certainly be a very good method; becauſe decrepitated Sea-ſalt powerfully attracts moiſture, and conſequently is very apt to imbibe and retain that which is in the Ardent Spirit: and Spirit of Wine doth not diſſolve Sea-ſalt; ſo that there is no reaſon to fear its being in the leaſt contaminated therewith.

All fermented liquors do not yield near an equal quantity of Ardent Spirit; becauſe they do not all, before fermentation, equally contain the principles neceſſary to produce an Ardent Spirit, in the moſt advantageous proportion or diſpoſition.

There are ſeveral ways of proving whether or no Spirit of Wine be as highly rectified as it poſſibly can be, that is, whether or no it contain any more phlegm than is preciſely neceſſary to conſtitute it Spirit of Wine; and many Chymiſts have judged that worthy of the title which burns away entirely, without leaving behind it the leaſt token of humidity; or that which, being burnt on gun-powder, fires it at laſt.

But Mr. Boerhaave juſtly obſerves, that neither of theſe is a ſufficient proof; becauſe, though there ſhould be a ſmall quantity of unneceſſary phlegm in Spirit of Wine, yet it may very well be evaporated and diſſipated by the deflagration in either way. He therefore propoſes another proof, which is much more to be depended on; that is, by mixing and ſhaking with the Spirit of Wine a ſmall quantity of a very dry pulverized Alkali. If this Salt, when thus agitated, and even warmed, with Spirit of Wine, continue as dry as it was at firſt, it is a ſign that the Spirit is perfectly dephlegmated.

Mr. Boerhaave tried in this manner ſome Spirit of Wine that had fired gun-powder, and found it to contain ſo much phlegm that it moiſtened his Salt very perceptibly: nay, one ſingle drop of water, being mixed with a conſiderable quantity of Spirit of Wine, which before left the Alkali perfectly dry, diſcovered itſelf in this way by the moiſture it communicated to the very ſame Salt.

Spirit of Wine may alſo be contaminated with ſome heterogeneous ſubſtances; ſuch as acid, alkaline, or oily matters. Theſe are to be diſcovered by very eaſy experiments proper to each: for an acid or alkalious Spirit of Wine being mixed with ſyrop of violets will give it a red or a green colour, according to the nature of the ſaline matter contained in it; and, if it be combined with an Oil, that will ſhew itſelf by the white milky colour which a drop of it will give to water.

Beſides the Ardent Spirit, Wine contains an Acid united with a portion of earth and of Oil, which give the Acid a concrete form. This ſubſtance generally ſeparates ſpontaneouſly from the Wine, and adheres, in the form of a ſtrong cruſt, to the ſides of the caſk. It is called *Tartar*, and is, properly ſpeaking, the Eſſential Salt of Wine. We ſhall exhibit the analyſis of Tartar, and treat of it more at length, in a chapter apart.

Wine-lees conſiſt of the groſſeſt parts of the fermented liquor; which being uncapable of remaining diſſolved, ſink to the bottom, and form a ſediment, which contains alſo ſome Tartar and a little Ardent Spirit.

The reſidue left in the cucurbit, after the Spirit is drawn off, is a ſort of Extract of Wine. This liquor hath an exceeding rough, or rather acid taſte. When diſtilled it yields an acid phlegm, which comes more and more acid as the diſtillation advances, and a fetid empyreumatic Oil. From the *caput mortuum*, when burnt, a conſiderable quantity of a Fixed Alkali may be extracted.

From all this it follows, that Wine conſiſts of an Ardent Spirit, and a Tartarous Acid, diffuſed through a great quantity of water, together with ſome oily and earthy parts.

Malt-liquor contains much leſs Tartar than Wine; but, inſtead thereof, it is impregnated with a mucilaginous matter, which becomes very perceptible when any body is ſmeared with it and dried; for then it makes a kind of Varniſh. This mucilaginous matter, which is not ſufficiently attenuated, eſpecially when the Malt-liquor is new, makes it very apt to ſwell up and riſe over the helm with rapidity, in the diſtillation of an Ardent Spirit from it: for which reaſon it is neceſſary to proceed more cautiouſly, and more ſlowly, in diſtilling a Spirit from this liquor than from Wine.

PROCESS III.

To dephlegmate Spirit of Wine by the means of Fixed Alkalis. Spirit of Wine analyzed.

INTO a glaſs cucurbit pour the Spirit of Wine you intend to dephlegmate, and add to it about a third part of its weight of Fixed Alkali, newly calcined, perfectly dry, heated, and pulverized. Shake the veſſel, that the two matters may be mixed and blended together. The Salt will gradually grow moiſt, and, if the Spirit of Wine be very aqueous, melt into a liquor, that will always lie at the bottom of the veſſel, without uniting with the Spirit of Wine which will ſwim at top.

When you perceive that the Alkali attracts no new moiſture, and that no more of it melts, decant your Spirit of Wine from the liquor beneath it, and add to your Spirit freſh Salt thoroughly dried as before. This Salt will alſo imbibe a little moiſture; but it will not grow liquid, becauſe the Alkali, with which it was mixed before, hath left too little phlegm to melt this. Decant it from this Salt as at firſt, and continue to mix and ſhake it in the ſame manner with freſh Salt, till you obſerve that the Salt remains as dry after as it was before mixing it with the Spirit of Wine. Then diſtil your Spirit in a ſmall alembic with a gentle heat, and you will have it as much dephlegmated as it can be.

OBSERVATIONS.

NEXT to the Mineral Acids, Fixed Alkalis perfectly calcined are the ſubſtances which have the greateſt affinity with water, and therefore it is no wonder they are ſo very fit to dephlegmate Spirit of Wine, and to free it from all its redundant humidity. Indeed Spirit of Wine cannot be perfectly dephlegmated without their aſſiſtance: for when diſtillation alone is made uſe of for that purpoſe, it is impoſſible to prevent ſome phlegm from riſing with the Spirit of Wine, whatever precautions we take to avoid it. Hence it comes to paſs, that Spirit of Wine, though ever ſo highly rectified by diſtillation, always imparts a little moiſture to an Alkali, when mixed with it in order to prove its goodneſs.

But, while the Alkali attracts the ſuper-abundant phlegm of the Spirit of Wine, it produces in that liquor, and undergoes itſelf, remarkable changes.

Spirit of wine, when ſo highly dephlegmated by an Alkali that, being kept in digeſtion therewith, it leaves the Salt perfectly dry, hath a red colour, an odour ſomewhat different from that which is peculiar to it when perfectly pure, a taſte in which that of the Fixed Alkali may be diſtinguiſhed; and it makes a ſlight effervescence with Acids: which manifeſtly proves, that it is united with a portion of the Alkali employed to rectify it.

Mr. Boerhaave thinks, with great probability, that this portion of the Alkali unites with the Spirit of Wine, much in the ſame manner as with Oils, *viz.* that it forms with the Spirit a kind of liquid Soap. He obſerves, that this alkalizated Spirit cleans the fingers; and that things wetted with it do not dry ſo ſpeedily as thoſe wetted with pure Spirit of Wine. This alkalizated Spirit is alſo called *Tincture of Salt of Tartar.*

In making this Alkaline Tincture, great care is to be taken that the Spirit of Wine you uſe be as highly rectified as poſſible: for, as long as it communicates any phlegm to the Alkali, it doth not acquire from the Salt mixed with it either the red colour, or the other properties which ſhew it to have diſſolved part thereof. It is alſo a rule, to throw the Alkali exceeding hot into the Spirit of Wine, which being heated beforehand boils on the addition of the hot Salt. In order to render the Tincture ſtill ſtronger, they are left to digeſt together for ſome time; after which, if part of the Spirit of Wine be drawn off by diſtillation, the remainder will have a redder colour and a more acrid taſte.

The Spirit drawn off by diſtillation is clear, colourleſs, and doth not give the ſame tokens of an alkaline quality as the Tincture; and for that reaſon, as the deſign of the preſent proceſs is only to dephlegmate and rectify Spirit of Wine by means of a Fixed Alkali, we have directed it to be diſtilled as ſoon as all its phlegm is abſorbed by the Salt.

However, Spirit of Wine rectified in this manner muſt not be conſidered as abſolutely pure; for a ſmall degree of an alkaline quality is ſtill perceptible in it: but that doth not hinder its being employed with ſucceſs in ſeveral chymical operations, where the property chiefly required in Spirit of Wine is that it be perfectly dephlegmated.

In order to free Spirit of Wine from the ſmall portion of Alkali remaining in it after diſtillation, Mr. Boerhaave propoſes to mix with it a few drops of the Vitriolic Acid, before the laſt diſtillation. But there is great reaſon to apprehend an oppoſite inconvenience from this practice: that is, inſtead of an alkaline character, we may give the Spirit an acid taint. Indeed this cannot be avoided, but by mixing with the Spirit of Wine exactly as much Acid, as ſuffices to ſaturate the Alkali contained in it, and no more; which is a point very difficult to hit.

Van Helmont tells us, that having diſtilled Spirit of Wine from Salt of Tartar perfectly calcined, half of it came over pure water; and Mr. Boerhaave, to whom this appeared very ſurpriſing, reſolved to repeat Van Helmont's experiment, in order to ſatisfy himſelf of the truth, and ſee with his own eyes what would be the reſult. With this view he made a tincture of Salt of Tartar in the manner above deſcribed, as ſtrong and as fully impregnated as he poſſibly could. He ſet it in digeſtion with the Alkali for ſeveral months, and afterwards let it ſtand four years without touching it. He then poured the whole into a cucurbit, and drew off the Spirit of Wine from the Salt by diſtillation. The Spirit of Wine, which was before very red, became clear on being diſtilled, having left its colour in the Salt which remained at the bottom of the cucurbit. This Spirit he returned upon the Salt, and diſtilled as before. He obſerved, that, in this ſecond diſtillation, the Spirit of Wine roſe with a little more difficulty, and that the remaining Salt was of a more ſaturated colour, and become of a dark red. In this manner he cohobated and diſtilled his Spirit twenty times, with the ſame Salt. He then found that the Spirit of Wine had acquired a cauſtic, fiery taſte, and that the ſaline maſs in the bottom of the cucurbit was grown black. This ſaline reſidue he diſtilled with a ſtronger fire, and obtained from it a liquor, which was water, and not Spirit of Wine.

Though Mr. Boerhaave ſeems, by this tedious labour, to have made Van Helmont's experiment ſucceed, at leaſt in part, yet that famous and accurate Philoſopher did not flatter himſelf with the notion of having ſolved the problem. He firſt obſerves, that he was far from getting the quantity of water which Van Helmont ſays he obtained, *viz.* half the weight of the Spirit of Wine. Secondly, he could ſcarce think that the quantity he did obtain actually came from the Spirit of Wine. The thing appeared to him ſo ſingular, and ſo hard to be accounted for, that he inclined to believe the water was quite extraneous both to his Spirit of Wine and to his Salt, and that it came from the air, which could not but be admitted in the frequent cohobations of the Spirit of Wine with the Alkali.

When Mr. Boerhaave undertook this long laborious courſe of operations, he had it alſo in his view to try whether he could not, by the ſame means, ſolve another problem famed among the Chymiſts, namely, the Volatilization of the Salt of Tartar. He acquaints us, that in this alſo he failed; which may eaſily be belived: but, in my opinion, he was more ſucceſsful with regard to the firſt point, than he himſelf imagined; for I think the water he obtained came immediately from the Spirit of Wine. We ſhall eaſily be convinced of this, if we carefully conſider all the circumſtances attending his experiments.

It hath been ſhewn, that Spirit of Wine conſiſts of an Oil, of an Acid, and of water, with which the Oil is intimately mixed by means of the Acid; that Spirit of Wine, which is not perfectly dephlegmated, may be deprived of a pretty conſiderable quantity of Water, which is ſuperfluous and unneceſſary to its compoſition; and that it ſuffers no change thereby, except that it becomes lighter, ſtronger, more inflammable, in ſhort, more Spirit of Wine: but that, when it is once freed of this ſuper-abundant phlegm, it would be in vain to attempt ſeparating a greater quantity of water from it. All the water then left in it is eſſential to its compoſition, and neceſſary to give it its properties; for, without that, it would not be Spirit of Wine, but only an Oil loaded with an Acid.

This being laid down, the water which cannot be ſeparated from Spirit of Wine while it continues Spirit of Wine, muſt become ſenſible when it is decompoſed. And this actually comes to paſs: for if you rob Spirit of Wine of one of its principles, its Oil, for inſtance, and for that purpoſe burn it under a glaſs bell, as you do Sulphur, you will by this means collect a great quantity of water, even though you make uſe of the moſt highly rectified Spirit of Wine;

which proves that this water was one of the eſſential parts that conſtituted the Spirit.

If, inſtead of depriving this mixt of its oily principle, you ſeparate from it one of its other principles, ſuch as its Acid, it is plain that it will in like manner be decompoſed, and that then the Oil and the water, which were combined together only by means of that Acid, will ſeparate from one another, and appear each in its natural form. Now this is exactly the caſe in Van Helmont's experiment, as repeated by Boerhaave. The Fixed Alkali, on which the Spirit of Wine is cohobated, hath a greater affinity with the Acid of this mixt than with its phlegm or its Oil. It therefore unites with part of that Acid; by which means a proportional quantity of its Oil and water muſt needs ſeparate from each other, and of courſe a portion of the Spirit of Wine will be decompoſed. Accordingly Boerhaave obſerved, that, in dephlegmating Spirit of Wine by a Fixed Alkali, a portion of Oil is always ſeparated from it, and that the Alkali employed in this operation is impregnated with an Acid, ſo that, when it hath been ſeveral times uſed for this purpoſe, it is almoſt changed into a Neutral Salt, and hath acquired the properties of the Foliated Salt of Tartar. That on which Spirit of Wine hath been cohobated a great number of times muſt conſequently be impregnated with a great quantity of Acid; and, as the Acid carries with it a great deal of water, it is not ſurpriſing that when the Alkali, thus impregnated with Acid and phlegm, is expoſed to a ſtrong fire, the phlegm ſhould be ſeparated from it: ſeeing the union between them is but weak.

Thus it appears that the water obtained by Mr. Boerhaave, in his experiment, came immediately from the Spirit of Wine, agreeably to Van Helmont's notion; whoſe moſt intelligent followers have clearly explained his ſentiments on this ſubject, telling us, as their author's poſitive aſſertion, that, "in his experiment, the pureſt Spirit of Wine depoſites one of its principles in the Salt of Tartar; that another of them is turned into water, and ſo ſeparated from that Spirit, and from the principle attracted by the Salt of Tartar; that conſequently Spirit of Wine certainly conſiſts of theſe two principles, which may be ſeparated from each other; and that the principle which unites with the Alkali of the Tartar changes this Salt into a medicament, or Balſam, of admirable virtue in curing wounds, known by the title of the *Samech* of *Paracelſus*."

It may here be aſked, why Boerhaave obtained but a ſmall quantity of water in this experiment, ſeeing Van Helmont pretends that it ought to be equal to half the weight of the Spirit of Wine. The moſt natural anſwer to this queſtion is, that, as Van Helmont did not publiſh all the circumſtances of his experiment, there is reaſon to think Boerhaave did not go about it in the ſame manner as Van Helmont did.

In my opinion he would have ſucceeded perfectly, and have obtained from his Spirit of Wine the whole quantity of water he deſired, if, inſtead of cohobating it always on the ſame Alkali, he had taken freſh Alkali every time; had drawn a tincture from it; had diſtilled his Spirit of Wine from this Salt; and, after collecting all the parcels of Alkali remaining after thoſe diſtillations, he had expoſed them to a ſtrong fire, in order to ſeparate all the moiſture contained in them. Perhaps alſo ſuch a great number of cohobations and diſtillations would not have been neceſſary to decompoſe the Spirit of Wine totally by this method; eſpecially if he had employed a greater quantity of Alkali in each operation. For it is evident, that a Fixed Alkali, by being impregnated with a certain quantity of the Acid and water of the Spirit of Wine, loſes thereby a great deal of its ſtrength and activity, and at laſt becomes incapable of abſorbing any more; ſo that, when it is entirely ſaturated, it is no more able to act upon Spirit of Wine, ſo as to decompoſe it, than ſo much Vitriolated Tartar, or common Sand. Hence you ſee, that there are ſtill many beautiful experiments to be made on this ſubject, and that we may hope by a regular courſe of them to obtain a perfect ſolution of Van Helmont's problem.

In the following proceſſes we ſhall treat of another method of decompoſing Spirit of Wine, which conſiſts in depriving it of its eſſential water, or aqueous principle, by the means of highly concentrated Acids.

CHAP. II.

SPIRIT OF WINE *combined with* DIFFERENT SUBSTANCES.

PROCESS I.

To combine Spirit of Wine with the Vitriolic Acid. This combination decompounded. Rabel's Water. Æther. Sweet Oil of Vitriol. Hoffman's Anodyne Mineral Liquor.

INTO an Engliſh glaſs retort put two pounds of Spirit of Wine perfectly dephlegmated, and pour on it at once two pounds of highly concentrated Oil of Vitriol: ſhake the retort gently ſeveral times, in order to mix the two liquors. This will produce an ebullition, and conſiderable heat; vapours will aſcend, with a pretty loud hiſſing noiſe, which will diffuſe a very aromatic ſmell, and the mixture will be of a deeper or lighter red colour, according as the Spirit of Wine was more or leſs oily. Set the retort on a ſand-bath, made nearly as hot as the liquor; lute on a tubulated ballon, and diſtil the mixture with a fire ſtrong enough to keep the liquor always boiling: a very aromatic Spirit of Wine will firſt come over into the ballon, after which the Æther will riſe. When about five or ſix ounces of it are come off, you will ſee in the upper concavity of the retort a vaſt number of little points in a veined form, which will appear fixed, and which are nevertheleſs ſo many little drops of Æther, rolling over one another, and trickling down into the receiver. Theſe little points continue to appear and ſucceed each other to the end of the operation. Keep up the ſame degree of fire, till upon opening the little hole in the ballon you perceive that the vapours, which inſtantly fill the receiver, have the ſuffocating ſmell of volatile Spirit of Sulphur *.

Then

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* Theſe white vapours do not appear when the veſſels are perfectly cloſe. Mr. Hellot, to whom we owe the remark, having performed this operation in a cryſtal retort procured from London, the neck of which had been rubbed with emery in the mouth of its receiver, ſo that theſe two veſſels fitted each other exactly, ſaw the ætherial liquor diſtil pretty faſt, but without white vapours. He then looſened the receiver, by turning it a little upon

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Then unlute the ballon, pour the liquor it contains into a cryſtal bottle, and ſtop it cloſe: there will be about eighteen ounces of it. Lute on your receiver again, and continue the diſtillation with a greater degree of fire. There will come over an aqueous, acid liquor, ſmelling ſtrong of a ſulphureous ſpirit, which is not inflammable. It will be accompanied with undulating vapours; which being condenſed will form an oil, moſt commonly yellow, one part of which will float on the ſurface of the liquor, and another will ſink to the bottom.

Towards the end of the diſtillation of this acid liquor, and of the yellow Oil of which it is the vehicle, that part of the mixture, which is left in the retort and grown black, will begin to riſe in froth. Then ſuppreſs your fire at once: ſtop the diſtillation, and change your receiver once more. When the veſſels are grown pretty cool, finiſh your diſtillation with a lamp-heat, kept up for twelve or fifteen days, which in all that time will raiſe but a very little ſulphureous ſpirit. Then break your retort, in which you will find a black, ſolid maſs, like a Bitumen. It will have an acid taſte, ariſing from a remainder of the Acid imperfectly combined with Oil.

This artificial Bitumen may be freed from its redundant Acid, by waſhing it in ſeveral waters. Then put it into a glaſs retort, and diſtil it with a ſtrong reverberated fire. You will obtain a reddiſh Oil that will ſwim on water, much like the Oil obtained by diſtilling the natural Bitumens. This Oil alſo will be accompanied with an aqueous acid liquor. In the retort will be left a charred matter, which, being put into an ignited crucible in the fire, burns for ſome time, and, when well calcined, leaves a white earth.

The liquors that riſe firſt in this diſtillation, and which we directed to be kept by themſelves, are a mixture conſiſting, 1. of a highly dephlegmated Spirit of Wine, of a moſt fragrant ſmell; 2. of Æther, which the Spirit of Wine wherewith it is united renders miſcible with water; 3. of a portion of Oil, which commonly riſes with the Æther, towards the end of the operation; 4. and ſometimes of a little ſulphureous acid, if the receiver be not changed ſoon enough.

In order to ſeparate the Æther from theſe other ſubſtances, put the whole into an Engliſh retort, with a little Oil of

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the neck of the retort, ſo that the external air might get in; whereupon the white vapours appeared immediately. When the receiver was cloſe fitted on again, the vapours diſappeared. He repeated the ſame thing five times from half hour to half hour, and theſe vapours as often appeared and diſappeared.

Tartar *per deliquium* to abſorb the Sulphureous Acid, and diſtil very ſlowly in a ſand-bath heated by a lamp, till near half the liquor be come over. Then ceaſe diſtilling; put the liquor in the receiver into a phial with ſome water and ſhake it; you will ſee it riſe with rapidity to the upper part of the phial, and float on the ſurface of the water: this is the Æther.

OBSERVATIONS.

THIS operation is only a decompoſition of Spirit of Wine by means of Oil of Vitriol. In the preceding proceſs we ſaw that this Spirit, which conſiſts of three eſſential principles, *viz.* an Oil, an Acid, and Water, cannot be deprived of one of them without being at the ſame time decompoſed; the two others that remain having, by ſuch ſeparation, loſt the bond of intimate union and connection that was between them. We ſaw alſo that Spirit of Wine, when mixed and digeſted with a very cauſtic Fixed Alkali, and ſeveral times diſtilled from it, depoſites its Acid in that Salt: and hence it comes that the Oil and the Water, being deprived of the principle which was the bond of their union, ſeparate from each other, and appear in their natural forms.

In the preſent experiment, the Vitriolic Acid decompoſes the Spirit of Wine in a different manner. We know that this Acid acts powerfully on Oils; and that, when it is highly concentrated, as the operation requires it ſhould be, it ſeizes and attracts with ſurpriſing force the moiſture of all bodies that touch it. So that, when it is mixed with Spirit of Wine, it acts at the ſame time both on the aqueous and on the oily principle of that mixt. The rapidity and activity, wherewith it ruſhes into union with theſe ſubſtances, produce the heat, the ebullition, and the hiſſing noiſe, which we obſerve during the firſt moments after their mixture.

The red colour, which the two liquors confounded together acquire after ſome time, is owing to the combination of the acid with the oily part; for it is known that Oils, as colourleſs as Spirit of Wine, ſuch as the Eſſential Oil of Turpentine, become of a browniſh red when diſſolved by a concentrated Acid: and Kunckel obſerved, that, the more Oil there is in Spirit of Wine mixed with Oil of Vitriol, the deeper is the red colour it acquires on being ſo mixed. He even gives this experiment as the certain means of diſcovering whether Spirit of Wine be more or leſs oily; and he adds, that Spirit of Wine, which hath loſt part of its Oil by being rectified with Lime, acquires leſs redneſs than any other by being mixed with Oil of Vitriol.

When the mixture hath acquired this colour, and before it undergoes diſtillation, it appears like a homogeneous liquor. There is yet no decompoſition; or at leaſt none that is perceptible; and the Vitriolic Acid is united at the ſame time with the Oil, the Acid, and the Water of the Spirit of Wine; that is, with the whole Spirit of Wine in ſubſtance. This mixture, when made with three parts of Spirit of Wine to one of Oil of Vitriol, is an aſtringent remedy much uſed in hemorrhages, and known by the name of *Rabel's Water*.

The actual decompoſition of the Spirit of Wine is effected by the diſtillation. The firſt liquor, or the firſt portion of the liquor that riſes before the reſt, hath the ſmell and all the properties of Spirit of Wine. It is indeed part of the Spirit of Wine employed as an ingredient in the mixture; but, being abſtracted from a highly concentrated Oil of Vitriol, which, of all known ſubſtances, attracts moiſture with the greateſt power, it is perfectly freed of all its unneceſſary phlegm, and retains no more than what is a conſtituent part thereof, as one of its principles, without which it would not be Spirit of Wine.

The liquor that ſucceeds this firſt Spirit of Wine is of a different nature. It may be conſidered as an Æther: for, though it be not a pure Æther, it contains the whole of it: from this liquor only can it be obtained; it is no other than an Æther mixed with ſome of the Spirit of Wine that comes over firſt, and a little of the acid liquor which comes afterward. Now the production of Æther is the effect of a beginning decompoſition of the Spirit of Wine: it is Spirit of Wine degenerated, half decompoſed; Spirit of Wine too highly dephlegmated; that is, Spirit of Wine which hath loſt a part of its eſſential phlegm, of that phlegm which as a neceſſary principle made it Spirit of Wine: it is a liquor ſtill compoſed of oily parts mixed with aqueous parts, and on that account muſt retain a reſemblance of Spirit of Wine; but ſuch that its oily parts, not being diſſolved and diffuſed among a ſufficient number of aqueous particles, are brought nearer to each other than they ſhould be to conſtitute perfect Spirit of Wine; on which account it is not now miſcible with water, but is as much nearer to the nature of Oil, as it is removed from the nature of Spirit of Wine: it is a liquor, in ſhort, which, being neither Spirit of Wine nor pure Oil, yet poſſeſſes ſome properties in common with both, and is conſequently to be ranked in the middle between them.

This explanation of the nature of Æther, which I imagine was never before given by any other, is the ſame that we propoſed in our Elements of the Theory of Chymiſtry, which may be conſulted on this occaſion.

An objection againſt this opinion may, perhaps, be drawn from an experiment well known in Chymiſtry. It may be ſaid, that, if Æther were nothing but depraved Spirit of Wine, which ceaſes to be miſcible with water, becauſe the loſs it hath ſuſtained of a portion of the water neceſſary to its conſtitution hath diſordered the proportion which ought to ſubſiſt between its aqueous and oily parts, from which proportion it derives that property, it would be very eaſy to change Spirit of Wine into Æther by a method quite contrary to the uſual one; *viz.* by mixing Spirit of Wine with a ſufficient quantity of ſuperfluous Oil: for it ſeems to be a matter of indifference whether the proportion, between the aqueous and the oily parts of Spirit of Wine, be changed by leſſening the quantity of the former, as in the common operation for Æther, or by increaſing the quantity of the latter, as is here propoſed; and we can, by the laſt method, put theſe two principles together in what proportion we pleaſe. Now it is certain that, whatever quantity of Oil be diſſolved in Spirit of Wine, it will ſtill remain miſcible with water; and that, if Spirit of Wine thus replete with Oil be mixed with water, it will unite therewith as uſual, and quit the Oil which it had diſſolved.

This objection, though ſeemingly a very ſpecious one, will be removed with the utmoſt eaſe, if we reflect but ever ſo little on ſome of the principles already laid down. We ſaid, and we gave ſome inſtances of it, that certain ſubſtances may be united together in ſundry different manners: ſo that from theſe combinations, though made in the ſame proportions, there ſhall reſult compounds of very diſſimilar properties. The combination we are now conſidering is another evidence of this truth. It is allowed that the proportion between the oily and the aqueous parts may be exactly the ſame in Æther and in Spirit of Wine replete with Oil; but it muſt alſo be owned that the manner in which the Oil is combined in theſe two caſes is very different.

That Oil, which at firſt is a conſtituting part of the Spirit of Wine, and afterwards becomes a part of the Æther, is united with the other principles of thoſe mixts, that is, with their Acid and their Water, by the means of fermentation, whereby it is much more attenuated, and much more cloſely combined, than that with which Spirit of Wine is impregnated by diſſolution only. And accordingly this adventitious Oil is ſo ſlighty connected with Spirit of Wine, that it is eaſily ſeparable from it by barely diſtilling it, or even mixing it with water: whereas that which makes a part of the Spirit of Wine, as one of its conſtituent principles, is united therewith in ſuch a manner as not to be ſeparable from it by either of theſe methods, nor indeed without employing the moſt vigorous and powerful agents for that purpoſe. So that the chief differences between Æther and Oily Spirit of Wine muſt be aſcribed to the different manner in which the Oil is combined in theſe two mixts: and, if a ſufficient quantity of ſuperfluous Oil could be united with Spirit of Wine, in ſuch a manner that, without being ſoapy, it ſhould not be ſeparable therefrom by the affuſion of water, I make no doubt but ſuch a Spirit of Wine would be perfectly like Æther, ſo far as not to be miſcible with water.

But let us return to our diſtillation, and trace the decompoſition of the Spirit of Wine by the Vitriolic Acid. We have ſhewn that the Acid begins with attracting part of the Water which conſtitutes the Spirit of Wine, by which means it changes the nature of this compound, deſtroys its muſcibility with water, and brings it as much nearer to the nature of an Oil as it thereby removes it from the nature of Spirit of Wine.

According to the theory laid down it is evident, that, if the Acid continue to act in the ſame manner on Spirit of Wine thus depraved and become Æther; that is, if it continue to draw from it the ſmall remaining quantity of the aqueous principle, to which it owes the properties it ſtill retains in common with Spirit of Wine, this muſt produce a total decompoſition thereof; ſo that the oily parts, being no longer diſſolved and divided by the aqueous parts, will be collected together, unite, and appear under their natural form, with all their properties. Now this is exactly the caſe. The Vitriolic Acid riſes in the diſtillation after the Æther; but conſiderably changed, becauſe it is loaded with the ſcattered remains of the decompoſed Spirit of Wine. It is in a manner ſuffocated by the Water it hath attracted from the Spirit; which is the reaſon why it appears in the form of a very aqueous acid liquor. It carries up along with it the Oil which it hath ſeparated from that Water: this is the Oil we took notice of in the proceſs; and it is conſequently that very Oily principle which actually conſtituted the Spirit of Wine. Laſtly, by acting on this Oil alſo, it takes up a portion of phlogiſton, which renders it ſulphureous.

What remains in the retort is alſo a portion of the Oil, that was contained in the Spirit of Wine, now combined with ſome of the Acid; which is the reaſon why it is black and thick. It is a compound much reſembling a Bitumen, and when analyzed yields the ſame principles we obtain from native Bitumens, or from an Eſſential Oil thickened and half burnt by its combination with concentrated Oil of Vitriol.

As to the Acid of the Spirit of Wine, ſome of it remains combined with the Æther: but there is great reaſon to think, that, when the Vitriolic Acid robs the Spirit of Wine of its aqueous part, it takes up at the ſame time moſt of its Acid, which being itſelf very aqueous, may be conſidered as pure water with reſpect to the concentrated Oil of Vitriol, by which it is attracted, and with which it is confounded.

The properties which characteriſe Æther agree perfectly well with what we have ſaid of its nature, and of the manner in which it is produced. It is one of the lighteſt liquors we know; it evaporates ſo ſuddenly, that, if a little of it be dropt on the palm of your hand, you will ſcarce perceive the part it touches to be wet by it; it is more volatile than Spirit of Wine; which is not at all ſurpriſing, ſeeing it differs therefrom only by containing leſs water, which is the heavieſt principle in Spirit of Wine.

Æther is more inflammable than Spirit of Wine; for, if any flame be brought but near it, it immediately catches fire. The reaſon of this is, that the oily parts of which it conſiſts are not only as much attenuated, and as ſubtile, as thoſe of Spirit of Wine, but alſo in a greater proportion with regard to its aqueous parts. To the ſame cauſe muſt be attributed the facility with which it diſſolves any oily matters whatever.

Æther burns without ſmoke, as Spirit of Wine does, and without leaving any coal or earthy matter behind; becauſe the inflammable or oily parts contained in it are, in this reſpect, diſpoſed like thoſe of Spirit of Wine.

The properties of not being miſcible with water, and of taking up Gold diſſolved in *aqua regis*, it poſſeſſes in common with Eſſential Oils; but the latter property it poſſeſſes in a much more ſenſible degree than any Oil: for Eſſential Oils ſuſtain the Gold they thus take up but a little while; whereas the Æther never lets it fall. It ſeems the ancient Chymiſts were unacquainted with the Æther: or at leaſt, if they did know it, they made a myſtery of it, according to cuſtom, and ſpoke of it only in enigmatical terms. Amongſt the moderns Frobenius, a German Chymiſt, ſeems to have been the firſt who brought it to perfection. Godfrey Hankwitz, alſo a German, but ſettled in England, made mention of it much about the ſame time in the Philoſophical Tranſactions. According to the latter, Mr. Boyle and Sir Iſaac Newton both knew the preparation of Æther, for which they had each a different proceſs. But none of theſe Chymiſts ever publiſhed an exact and circumſtantial account of a method by which this liquor might be prepared: ſo that Meſſrs. Duhamel, Groſſe, and Hellot, who have ſince made ſeveral experiments for that purpoſe, and have diſcovered, and communicated to the public, eaſy and certain methods of procuring Æther, had no aſſiſtance in their labours but from their own ſkill and ſagacity; which gives them a juſt title to the honour of the invention. Mr. Beaumé alſo, a very ingenious Artiſt in Paris, who hath beſtowed a great deal of pains on this ſubject, lately communicated to the Academy a Memoir, which, among ſeveral very important obſervations, contains the commodious and expeditious proceſs above inſerted. As there are many experiments in Mr. Hellot's Memoir, agreeing perfectly well with what hath been ſaid concerning the decompoſition of Spirit of Wine by the Vitriolic Acid, we think it will be proper to take notice of them here, and to examine them briefly at leaſt.

The quantity, the colour, and the weight of the Oil, which riſes in the diſtillation at the ſame time with the aqueous acid liquor, are various, according to the different proportions of Spirit of Wine and Oil of Vitriol that are mixed together. Mr. Hellot obſerved that by increaſing the quantity of the Vitriolic Acid he obtained more of this Oil, and leſs of the Ardent Spirit containing the Æther. The reaſon is this: the more Oil of Vitriol you put in the mixture, the more Spirit of Wine muſt be totally decompoſed, and conſequently the more of this Oil will be obtained; which, as we have ſhewn, is one of the principles reſulting from the decompoſition of Spirit of Wine.

" This Oil is alſo lighter or heavier, in proportion to the " quantity of Oil of Vitriol poured on the Spirit of Wine. " That which ariſes from mixing ſix, five, four, or even " three parts of Spirit of Wine with one part of concentrated Oil of Vitriol, always floats on the water, and continues white. That which aſcends from two parts of Spirit " of Wine is yellow, and moſt commonly ſinks; and, laſtly, " that which is produced from equal parts of theſe two liquors is greeniſh, and conſtantly falls to the bottom."

Mr. Hellot remarks, on this occaſion, that part of the Acid, by the intervention of which this Oil is ſeparated, unites therewith; and, to the greater or ſmaller quantity of the Acid thus combined with the Oil, he imputes its being more or leſs ponderous: which is the more probable, as the heavieſt Oil is always obtained from a mixture in which the Acid bears the greateſt proportion, and *vice verſa*. Perhaps the different ſpecific gravity of Eſſential Oils is wholly owing to the greater or ſmaller quantity of Acid they contain.

Mr. Hoffman hath made ſeveral obſervations on this Oil, which evidently prove that it contains much Acid. He ſays, that, if it be kept for ſome time in a bottle, it grows red, and loſes its tranſparency; that its agreeable aromatic taſte becomes acid and corroſive; and that if you hold it over the fire in a ſilver ſpoon, it corrodes it, and leaves a black ſpot on it; and that it alſo corrodes Mercury, when heated therewith in a matraſs. To this Mr. Pott adds, that it makes a very perceptible effervéſcence with Fixed Alkalis; and that being rectified by thoſe ſalts it loſes all the acid properties obſerved by Mr. Hoffman.

Mr. Hellot obtained a ſtill more conſiderable quantity of this Oil, by adding three or four ounces of a Fat Oil to the mixture of Spirit of Wine with the Vitriolic Acid. Now, as the Oil we are ſpeaking of hath the properties of Eſſential Oils, and is ſoluble in Spirit of Wine, Mr. Hellot obſerves, that Oil of Vitriol by uniting with Fat Oils converts them into Eſſential Oils: which agrees very well with our opinion concerning the cauſe of the ſolubility of Oils in Spirit of Wine; which, in the Memoir already referred to on other occaſions, we attribute to an Acid ſuperficially and ſlightly united with Oils.

The Oil which thus riſes, in diſtilling Spirit of Wine mixed with the Vitriolic Acid, is known by the name of the *Sweet Spirit of Vitriol*. This name is very improper, becauſe it may ſuggeſt a notion that this Oil derives its origin from the Vitriolic Acid, as ſome Chymiſts have erroneouſly thought; whereas it comes entrely from the Spirit of Wine, as we have ſhewn. If any reaſon can be aſſigned for keeping up the name, it muſt be becauſe of the conſiderable quantity of the Vitriolic Acid that remains in the combination, and is dulcified by its union with the Spirit of Wine.

This Oil is an ingredient in Hoffman's famous *Anodyne Mineral Liquor*. That liquor is thought to be nothing but this very Oil diſſolved, and combined with the two liquors that riſe firſt in the diſtillation, and immediately before the ſulphureous acid phlegm. It diſſolves very eaſily and quickly in thoſe ſpirituous menſtrua; ſo that, if you intend to have it by itſelf, and to prevent its recombining with the liquors that come off before, (which ſhould be prevented, becauſe it hinders the ſeparation of the Æther), you muſt take great care to change the receiver as ſoon as the acid phlegm with which it riſes begins to appear.

We have ſeen that, by the methods which Mr. Hellot hath pointed out, this Sweet Oil of Vitriol may be increaſed, both in weight and quantity. In that ingenious Chymiſt's Memoir we alſo find ſome methods of preventing it from riſing in the diſtillation. They conſiſt wholly in the addition of ſome Abſorbent bodies, which, he tells us, divert the action of the Vitriolic Acid, at leaſt in ſome meaſure, from the inflammable part of the Spirit of Wine. One of theſe methods is as follows.

"Put into Spirit of Wine as much ſoft Soap as it can
" diſſolve: filter it, and pour on it ſome of the heavieſt and
" moſt concentrated Oil of Vitriol: ſhake the mixture.
" The Soap will be inſtantly decompounded, and its Oil
" will float on the ſurface; becauſe the Vitriolic Acid robs
" it of the Alkali, which renders it miſcible with Spirit of
" Wine. Diſtil it, and you will obtain but a very little of
" Rabel's water; which, moreover, will have the diſagree-
" able ſmell of a moſt rancid Oil. There will afterwards
" aſcend a great quantity of Spirit of Wine having the ſame
" ſmell; then an aqueous, acid, and ſulphureous liquor;
" but not a drop of yellow Oil. Mean time there forms a
" bituminous fungus, of ſome conſiſtence, riſing above the
" Oil of the Soap which floats on the reſt of the liquid."

Moſt of the Vitriolic Acid having been abſorbed by the Alkali of the Soap, in this experiment, as Mr. Hellot obſerves, it is not ſurpriſing that it ſhould not act upon the Spirit of Wine with ſo much efficacy as to decompoſe it, and ſeparate its Oil. For the ſame reaſon but a little of Rabel's Water comes over, and almoſt all the Spirit of Wine riſes without undergoing any ſenſible alteration. The diſagreeable ſmell of thoſe liquors comes from the Oil of the Soap, which, being naturally heavy, remains behind in the retort, where it grows rancid and is partly burnt.

The laſt experiment in Mr. Hellot's Memoir, of which we ſhall take notice, is a peculiar proceſs for preparing Æther; by means whereof, with the help of an earthy medium, it is eaſy to diſtil the vinous acid Spirit containing the Æther, without any ſenſible change of ſmell from the beginning to the end of the operation; without its being ſucceeded by an acid ſulphureous liquor, oil, black ſcum, reſin, or bitumen; and without the neceſſity of taking any great care about the management of the fire, as the liquor may always be kept boiling in the retort, and diſtilled to dryneſs without any danger. This medium is common potter's earth. Mr. Hellot puts ſix ounces thereof, well dried and pulverized, into a large retort, with one pound of Spirit of Wine and eight ounces of Oil of Vitriol. Theſe he digeſts together three or four days. The mixture acquires no ſenſible colour. He ſets the retort in a ſand-bath, and continues the diſtillation to dryneſs with a moderate charcoal fire. Excepting a few drops that riſe firſt, and which are pure Spirit of Wine, all the reſt of the liquor that diſtils hath conſtantly the ſmell of Æther: which is even ſomewhat more penetrating than that of the vinous acid Spirit obtained without the intervention of this earthy medium.

We have ſhewn, that the production of the æthereal liquor is owing to a ſemi-decompoſition of the Spirit of Wine effected by the Vitriolic Acid during the diſtillation; that this Acid continuing to act, produces a total decompoſition, or perfect ſeparation of the Oil and Phlegm of the Spirit of Wine from each other; and that the Vitriolic Acid, uniting with theſe two principles, forms the ſulphureous phlegm, the fluid oil, and the bituminous matter, all frequently mentioned above. Why then, in this experiment of Mr. Hellot's, do we obtain only a Spirit of Wine replete with Æther, while none of the other productions appear? The reaſon is a very natural one, and very clear: it is this; the potter's clay containing an earth of that kind which we called Abſorbent, becauſe it poſſeſſes the property of uniting with Acids, that earth joins with the Vitriolic Acid in the mixture, reduces it to a Neutral Salt, and thereby prevents its continuing to act upon the Spirit of Wine, as is neceſſary to the total decompoſition thereof.

Mr. Hellot ſays on this occaſion, "that part of the Vitriolic Acid turning its action on this ſoluble earth or bole, "which it finds in the potter's clay, ceaſes to act on the inflammable principle of the Spirit of Wine; that, conſequently, as there is not an immediate and continuous "combination of theſe two ſubſtances, neither a reſin nor a "bitumen can reſult therefrom. This is ſo true, that a great "part of the Oil of Vitriol may be afterwards recovered "from the potter's clay as colourleſs as when it was firſt "uſed."

Mr. Hellot makes uſe of the following method for procuring the Æther from the acid vinous Spirit obtained by this diſtillation. “ You muſt,” ſays he, “ put all this liquor “ into a glaſs body, made of one piece with its head; pour “ upon it, through the hole in the upper part of the head, “ twice or thrice as much well-water, the hardeſt to the “ taſte, and the moſt impregnated with gypſum, that can “ be got. Very pure water, he obſerves, produces much “ leſs Æther.

“ If the vinous acid Spirit have ſuch a ſulphureous ſmell, “ as to occaſion a ſuſpicion that it contains a little too much “ of a Volatile Vitriolic Acid, you muſt add to the water two “ or three drams of Salt of potaſh to abſorb that Acid; and “ then diſtil with a lamp-heat.

“ While any true Æther remains in the mixture, you will “ ſee it aſcend like a white pillar iſſuing from the midſt of “ the liquor, and conſiſting of an infinite number of air “ bubbles inexpreſſibly ſmall. Nothing ſeems to condenſe “ in the cavity of the head, which always remains clear, and “ without any viſible humidity. The gutts which light on “ the ſides of the receiver, inſtead of forming a net-work “ thereon, as Spirit of Wine doth when it is a little aqueous, ſpread to the breadth of two inches or more, when “ they conſiſt of true Æther. As ſoon as you perceive this “ track begin to grow conſiderably narrower, the fire muſt “ be put out; for what riſes afterwards will be mixed with “ water, and communicate that fault to the Æther already “ collected in the receiver.

“ Then pour this ætherial liquor into a long bottle, and “ add to it an equal quantity of well-water. Shake the bottle; the liquor will become milky, and the true Æther “ will inſtantly ſeparate, float upon the water, and mix no “ more with it. Separate it then by a ſiphon, and keep it “ in a glaſs bottle ſhut cloſe with a glaſs ſtopple.”

PROCESS II.

Spirit of Wine combined with Spirit of Nitre. Sweet Spirit of Nitre.

INTO an Engliſh retort of cryſtal glaſs put ſome highly rectified Spirit of Wine; and, by means of a glaſs funnel with a long pipe, let fall into your Spirit of Wine a few drops of the Smoking Spirit of Nitre. There will ariſe in the retort an effervefcence attended with heat, red vapours, and a hiffing noife like that of a live coal quenched in water. Shake the veffel a little, that the liquors may mix thoroughly, and that the heat may be equally communicated to the whole. Then add more Spirit of Nitre, but in a very fmall quantity, and with the fame precautions as before. Continue thus adding Spirit of Nitre, by little and little at a time, till you have put into the retort a quantity equal to a third part of your Spirit of Wine. Let this mixture ftand quiet, in a cool place, for ten or twelve hours; then fet it to digeft in a very gentle warmth for eight or ten days, having firft luted on a receiver to the retort.

During this time a fmall quantity of liquor will come over into the receiver, which muft be poured into the retort. Then diftil with a fomewhat ftronger degree of heat, but ftill very gently, till nothing be left in the retort but a thick matter. In the receiver you will find a fpirituous liquor, of a quick grateful fmell, which will excite a very fmart fenfation on the tongue, but without any corrofive acrimony. This is *The Sweet Spirit of Nitre.*

OBSERVATIONS.

By this operation Spirit of Nitre is combined with Spirit of Wine; thefe two liquors being united with each other, much in the fame manner as the Vitriolic Acid is with Spirit of Wine in Rabel's Water.

The proportion of the liquors which form this combination is not abfolutely determined, and the feveral authors who have written on the fubject differ much about it. Some require equal parts of the ingredients; others again from two as far as ten parts of Spirit of Wine to one of Spirit of Nitre. This depends on the degree to which the Spirit of Nitre made ufe of is concentrated, and on the greater or lefs acidity which your dulcified Spirit of Nitre is intended to have.

The Difpenfatory of the College of Paris orders one part of Spirit of Nitre diftilled from dried clay, that is, of Spirit which doth not fmoke, to be mixed with two parts of rectified Spirit of Wine, and the whole to ftand in digeftion for a month, without diftilling the mixture at all. This is a very good method: becaufe the long digeftion fupplies the place of diftillation, and the Spirit of Nitre, not being highly concentrated, doth not greatly alter the Spirit of Wine; befides that many inconveniences, to be prefently taken notice of, are by this means avoided.

But as our deſign is not to deſcribe ſuch Chymical preparations only as are commonly uſed in medicine, our plan requiring us to treat particularly of thoſe which may give any light into the fundamental properties of bodies, the proceſs here ſet down appeared the fitteſt for our purpoſe; becauſe the action which Spirit of Nitre exerts upon Spirit of Wine is therein ſtronger and more perceptible.

One of the firſt particularities attending the mixture of thoſe two liquors, is the great effervefcence, accompanied with violent heat, abundance of fumes, and loud hiſſing, which ariſes as ſoon as the Spirit of Nitre and the Spirit of Wine come into contact with each other. There is great reaſon to think, that theſe phenomena are produced only by the rapidity and vigour with which the Nitrous Acid ruſhes into union with the inflammable part of the Spirit of Wine. We obſerved, in treating of the Æther, that phenomena of the ſame kind appear at the inſtant when the Vitriolic Acid unites with Spirit of Wine: but on that occaſion, how highly ſoever the Vitriolic Acid be concentrated, all theſe effects are in a leſs degree than thoſe produced in the preſent experiment; becauſe the Nitrous Acid, though weaker than the Vitriolic, generally acts much more vigorouſly and violently on the bodies with which it unites, than any other ſort of Acid.

Concerning theſe mixtures of Acids with Spirit of Wine, Mr. Pott obſerves, that it is not a matter of indifference whether you pour the Spirit of Wine upon the Acid, or the Acid on the Spirit of Wine; but that every thing paſſes much more quietly, when the Acid is poured to the Spirit of Wine, than when the contrary is done: and he gives the true reaſon thereof; to wit, that when the Acid is poured on the Spirit of Wine it finds in that liquor a great quantity of water, with which it immediately unites; that this weakens it, and hinders it from acting on the inflammable part with ſo much impetuoſity as it otherwiſe would; and therefore he adviſes that ſuch mixtures be always made in this manner. But it is evident that this advantage is gained only by mixing the Acid with the Spirit of Wine very gradually, and drop by drop, as directed in the proceſs after Mr. Pott. For, if the two liquors were to be mixed together ſuddenly, and all at once, it is certain that the Acid would not meet with a ſingle drop of phlegm more or leſs in that way than in the other.

Therefore the chief, and, in ſome meaſure, the only precaution neceſſary to be taken, in the making of ſuch mixtures, to prevent the violent efferveſcence and other inconveniences that may attend it, ſuch as exploſion, and the burſting of the veſſels, is to pour but a very ſmall quantity of one liquor into the other at a time, and to add no more till the efferveſcence, and even the heat, produced by the firſt portion, be entirely ceaſed. With theſe precautions you may proceed either way, and be always ſure that the veſſels will not burſt; becauſe it is in your power to add ſuch a ſmall quantity of liquor at a time, as ſhall ſcarce produce a ſenſible efferveſcence. We own, however, that Mr. Pott's obſervation is a very juſt one. There is even an advantage in pouring the Acid to the Spirit of Wine, as he directs; which is, that the mixture is a little ſooner made, and without any danger.

We have ſhewn, that the Vitriolic Acid becomes aqueous and ſulphureous by mixing Spirit of Wine with it: the Nitrous Acid is changed by this mixture in a manner no leſs remarkable. Mr. Pott obſerves, that when Spirit of Nitre is dulcified, that is, when it is perfectly combined with Spirit of Wine, it loſes the diſagreeable odour peculiar to it, and acquires another that is quick and fragrant; it doth not afterwards emit any red fumes; it riſes with a leſs degree of heat than when pure; it acts with leſs vigour on Fixed Alkalis and Abſorbent earths. Laſtly, we ſhall here relate an experiment made by that Chymiſt, which ſeems to prove that the Nitrous Acid loſes its moſt characteriſtic properties, and entirely changes its nature, by being combined with Spirit of Wine.

Mr. Pott examined the thick liquor left in the retort, when the dulcified Spirit of Nitre is diſtilled off. By analyzing it he obtained an acid liquor, of a yellow colour, and of a ſomewhat empyreumatic ſmell. This Acid was followed by ſome drops of a red empyreumatic Oil; and there remained, at the bottom of the diſtilling veſſel, a black, ſhining, charred matter, like that which remains after the rectification of a fetid Oil.

The Oil extracted from this reſidue is a portion of that which helped to conſtitute the Spirit of Wine; being ſeparated therefrom by the Nitrous Acid, in the ſame manner as that treated of in the preceding proceſs, and called *Sweet Oil of Vitriol*, is ſeparated by the Vitriolic Acid. But as the Nitrous Acid, which is weaker than the Vitriolic, doth not ſo effectually decompoſe the Spirit of Wine, the Oil, obtained in the preſent experiment, is in ſmaller quantity than that procured in the diſtillation of a mixture of the Vitriolic Acid with Spirit of Wine.

As to the Acid which Mr. Pott drew off in his experiment, there is great reaſon to think it a part of that which was an ingredient in the mixture; namely, of the Nitrous Acid. And yet Mr. Pott having ſaturated with a Fixed Alkali one part of the reſiduum, which he had a mind to examine before the Acid was ſeparated from it by diſtillation, and expecting this matter to contain a regenerated Nitre, he threw it on a live coal; but was ſurpriſed to ſee it burn without the leaſt ſign of detonation; and thence concluded, that the Nitrous Acid had changed its nature. This experiment, he thinks, may furniſh hints for the tranſmutation of Acids; and he is of opinion, that the Nitrous Acid loſes its virtue of detonating, in the preſent caſe, only becauſe its inflammable part, to which it owes its diſtinguiſhing properties, hath deſerted it, and joined with that of the Spirit of Wine.

Indeed if the Acid obtained by Mr. Pott, which being reduced to a Neutral Salt doth not detonate, derives its origin from the Nitrous Acid that was combined with the Spirit of Wine, there is no doubt of its being depraved in a peculiar manner, and having entirely changed its nature. But may we not ſuppoſe it to have another origin? May it not be the Acid of the Spirit of Wine itſelf, reſulting from the decompoſition of that mixt in the diſtillation?

Mr. Navier, whom we mentioned in our Elements of the Theory, extracted a very ſingular oily liquor from the mixture of Spirit of Wine and Spirit of Nitre, without diſtillation, and even without the help of fire. He put equal parts of the two liquors, by meaſure, not by weight, into a bottle, which he ſtopped cloſe with a good cork, faſtened down with pack-thread. Nine days afterwards he found about a ſixth part of the mixture ſeparated from, and floating on, the reſt of the liquor. This was a very fine æthereal Oil, very limpid, and almoſt as colourleſs as water.

In another experiment Mr. Navier ſubſtituted a ſolution of Iron in the Nitrous Acid for pure Spirit of Nitre; and with this ſolution he mixed an equal weight of Spirit of Wine. From the mixture, after a fermentation which appeared in it, he obtained by the ſame method an æthereal Oil, like that of his former experiment; except that the latter, which was at firſt as colourleſs as the other, acquired a redneſs in the ſpace of about three weeks. He conjectures, with probability, that this colour proceeded from ſome particles of Iron which were united with it, and which gradually exhaled.

If a few drops of Oil of Tartar *per deliquium* be poured on this Oil, as ſoon as it is ſeparated, there appears at firſt no ſenſible change therein: but after ſome time needle-like cryſtals ſhoot in it, which are a true regenerated Nitre; and if the bottle be then unſtopped, the liquor emits a moſt pungent nitro-ſulphureous odour; which leaves no doubt of this Oil's containing a Nitrous Acid. When it is thus freed of its Acid, by means of the Oil of Tartar, it is much more volatile than before.

Neither the Vitriolic nor the Marine Acid is capable of ſeparating ſuch an Oil from Spirit of Wine: but the Nitrous Acid always produces it, even when it is not concentrated, and doth not ſmoke.

It is very certain that this Oil derives its origin from the Spirit of Wine: but there are not yet experiments enough made upon it, to enable us to ſpeak very accurately about the manner in which this liquor is formed, or of the cauſe of its ſeparation from the Spirit of Wine.

PROCESS III.

Spirit of Wine combined with the Acid of Sea-ſalt. Dulcified Spirit of Salt.

MIX together, little by little, in a glaſs retort, two parts of Spirit of Wine with one part of Spirit of Salt. Set this mixture to digeſt for a month in a gentle heat, and diſtil it, till nothing remain in the retort but a thick matter.

OBSERVATIONS.

THE Acid of Sea-ſalt is much leſs diſpoſed to unite with inflammable matters than the other two mineral Acids; and therefore, though it be ever ſo highly concentrated, when mixed with Spirit of Wine, it never produces an efferveſcence comparable to that which is produced by the Spirit of Nitre. Neither the proportion nor ſtrength of the Spirit of Salt, requiſite to prepare the Sweet Spirit of Salt, are unanimouſly agreed upon by Authors. Some direct equal parts of the two liquors; while others preſcribe from two to four or five parts of Spirit of Wine to one part of Spirit of Salt. Some uſe only common Spirit of Salt; others require the

Smoking Spirit, diſtilled by means of Spirit of Vitriol. Laſtly, ſome order the mixture to be diſtilled, after ſome days digeſtion; and others content themſelves with barely digeſting it. The whole depends on the degree of ſtrength which the Sweet Spirit of Salt is intended to have. This compoſition, as well as the Sweet Spirit of Nitre, is eſteemed in medicine to be very aperitive and diuretic.

When the mixture of Spirit of Salt and Spirit of Wine is diſtilled, there comes over but one liquor, which appears homogeneous. This is the Sweet Spirit of Salt. The nature of the Marine Acid is not changed in this combination: the Acid is only weakened and rendered more mild; but in other reſpects it retains its characteriſtic properties.

Some authors pretend, that an Oil is obtained by diſtilling the mixture for the Sweet Spirit of Salt; but others expreſsly deny the fact. This variety may be occaſioned by the quality of the Spirit of Wine employed. It would not be ſurpriſing if a Spirit of Wine, which contains much Oil that is unneceſſary to its nature, and, as it were, adventitious to it, ſhould yield an Oil when diſtilled with Spirit of Salt.

The thick reſidue, found in the retort after diſtillation, contains the moſt ponderous part of the Acid, united with part of the Spirit of Wine. If the diſtillation be continued to dryneſs, there remains in the retort a black charred matter, much like that which is left by the combinations of Spirit of Wine with the other Acids.

A ſweet Spirit of Salt may alſo be prepared by digeſting Spirit of Wine with, or diſtilling it from, metallic compoſitions replete with the Marine Acid adhering but ſlightly to them; ſuch as Corroſive Sublimate, and Butter of Antimony. Part of this Acid, which is very highly concentrated, quits the metallic ſubſtance with which it is but ſuperficially combined, in order to unite with the Spirit of Wine. If Butter of Antimony be uſed for this purpoſe, Mr. Pott, the author of theſe experiments, obſerves, that a *Mercurius Vitæ* precipitates; which is nothing elſe, as we obſerved in its place, but the reguline part of the Butter of Antimony deſerted by its Acid.

PROCESS IV.

Oils, or Oily Matters, that are ſoluble in Spirit of Wine, ſeparated from Vegetables, and diſſolved by means of that Menſtruum. Tinctures; Elixirs; Varniſhes. Aromatic Strong Waters.

PUT into a matraſs the ſubſtances from which you intend to extract a Tincture, having firſt pounded them, or pulverized them if they are capable of it. Pour upon them Spirit of Wine to the depth of three fingers breadth. Cover the matraſs with a piece of wet bladder, and tye it on with pack-thread. Make a little hole in this bit of bladder with a pin, leaving it in the hole to keep it ſtopped. Set the matraſs in a ſand-bath very gently heated. If the Spirit of Wine diſſolve any part of the body, it will accordingly acquire a deeper or lighter colour. Continue the digeſtion till you perceive that the Spirit of Wine gains no more colour. From time to time pull out the pin, to give vent to the vapours, or rarefied air, which might otherwiſe burſt the matraſs. Decant your Spirit of Wine, and keep it in a bottle well corked, Pour on ſome freſh Spirit in its ſtead; digeſt as before; and go on in this manner, pouring on and off freſh Spirit of Wine, till the laſt come off colourleſs.

OBSERVATIONS.

IT is commonly ſaid, that Spirit of Wine is the ſolvent of Oils and oily matters: but this propoſition is too general; for there are ſeveral ſorts of Oils and oily matters which this menſtruum will not diſſolve. Of this number are the Fat Oils, Bees-Wax, and the other Oily compounds of that kind. Properly ſpeaking, it diſſolves but two ſorts of oily ſubſtances; namely, Eſſential Oils, and Balſams or Reſins, which are matters of the ſame kind, differing from each other only as they are more or leſs thick; and Oils that are in a ſaponaceous ſtate.

In our Elements of the Theory we have explained our opinion on this head, from a Memoir on the ſubject printed among thoſe of the Academy for 1745. To repeat it in a few words: we take the cauſe of the ſolubility of Oils in Spirit of Wine to be an Acid, which is but ſuperficially united with them, and ſo as ſtill to retain its properties.

The principal proofs on which we found this opinion are drawn from that property of Eſſential Oils, Balſams, and Reſins, which are naturally ſoluble in Spirit of Wine, that they become ſo much the leſs ſoluble in this menſtruum, the oftener they are diſtilled or rectified; and from that property which Fat Oils, or other Oily matters, naturally indiſſoluble in Spirit of Wine, poſſeſs, of becoming more and more ſoluble therein the oftener they are diſtilled. We ſhewed that diſtillation leſſens the ſolubility of Eſſential Oils, Balſams, and Reſins, only by depriving theſe ſubſtances of part of the manifeſt Acid which they contain, and which is the cauſe of their ſolubility; and that Fat Oils, and other oily matters, naturally indiſſolvable in Spirit of Wine, are by the ſame operation rendered capable of diſſolving therein, only becauſe it diſcovers, and partly extricates, an Acid, which is naturally combined with them ſo intimately that it is entirely deprived of action, and all its properties perfectly maſked. If theſe principles be well attended to, and if it be recollected withal, that Spirit of Wine unites with Water preferably to Oils; inſomuch that, if it be mixed with water when it hath diſſolved an Oil, it quits the Oil to unite with the Water; that for the ſame reaſon it is not capable, when very aqueous, of diſſolving any Oil, ſeeing that, as Oil and water are not ſuſceptible of contracting any union, it muſt then deſert its phlegm to unite with the Oil; which it cannot do, becauſe it hath a greater affinity with phlegm than with Oil; and, laſtly, that if Oil be combined with any ſaline ſubſtance, which makes it ſoluble in water; that is, if it be in a ſaponaceous ſtate, it will then remain diſſolved in Spirit of Wine, without being precipitated by water; or will be diſſolved by a very aqueous Spirit of Wine, and frequently much better than by a highly rectified Spirit: if theſe things, I ſay, be conſidered, we ſhall eaſily perceive what muſt be the effect of digeſting Spirit of Wine with any vegetable ſubſtance whatever.

Spirit of Wine diſſolves all the Eſſential Oil, Balſam, and Reſin contained in any vegetable; and as theſe matters are not ſoluble in water, they may be ſeparated from the Spirit in which they are diſſolved, by lowering it with much water. It inſtantly becomes white and opaque, like milk; the oily parts gradually unite, and form conſiderable maſſes, eſpecially if they be reſinous. This is the method commonly made uſe of to extract the Reſin of Scammony, Jalap, Guaiacum, and ſeveral other vegetable ſubſtances, which it would be difficult to procure by any other means.

If the matters digeſted with Spirit of Wine contain any ſaponaceous juices, the Spirit will take up thoſe juices alſo. But as ſoaps are ſoluble in water, as well as in Spirit of Wine, they cannot be ſeparated, by the addition of water, from the Spirit in which they are diſſolved. Whatever quantity of water therefore you mix with a Spirit that is impregnated with ſuch juices, no ſeparation thereof will be produced; and for the ſame reaſon the ſaponaceous matters will be diſſolved by a very aqueous Spirit of Wine.

Spirit of Wine impregnated with ſuch parts of any vegetable ſubſtance, as it is capable of diſſolving, is commonly called a *Tincture*. Several Tinctures mixed together, or a Tincture drawn from ſundry vegetable ſubſtances at the ſame time, and in the ſame veſſel, take the name of an *Elixir*. Tinctures or Elixirs impregnated with Reſinous matters only are true *Varniſhes*. All theſe preparations are made in the ſame manner; to wit, as directed in our proceſs. We ſhall only add here, that if the ſubſtances from which a Tincture or Elixir is to be made contain too much moiſture, it is proper to free them from it by a gentle deſiccation; eſpecially if you deſign that the Tincture ſhould be well impregnated with the oily and reſinous parts: for their exceſs of moiſture uniting with the Spirit of Wine would weaken it, and render it unable to act on thoſe matters, which it cannot diſſolve when it is aqueous.

Vegetable ſubſtances which have been repeatedly digeſted with different parcels of Spirit of Wine, till the laſt would extract nothing, are deemed to be exhauſted of all their Eſſential Oils, and ſaponaceous juices: but if they contain moreover any Fat Oil, Wax, or Gum, theſe principles will ſtill remain therein after the digeſtion, in the ſame quantity as before; becauſe Spirit of Wine is incapable of diſſolving them.

With regard to the Fat Oil and Wax, this is not at all ſurpriſing: we have explained in another place why theſe matters are indiſſoluble by Ardent Spirits: but as for the Gum, it would ſeem, according to the general principles abovementioned, that it ſhould be ſoluble in that menſtruum, even with more eaſe than Reſins; as it conſiſts almoſt entirely of water, with which Spirit of Wine is known to unite more eaſily than with Oils. Indeed there is alſo a little Oil in its compoſition: but this Oil ſeems to be in a perfectly ſaponaceous ſtate; for Gum diſſolves wholly and eaſily in water, without leſſening its tranſparency in the leaſt.

I own that it is extremely difficult to give a very ſatisfactory account of this matter. We may however venture to throw out ſome conjectures concerning it, deduced from what hath been already ſaid, relating to the cauſe of the ſolubility of Oils in Spirit of Wine. We ſhewed that the Oils which diſſolve in this menſtruum derive that property from a manifeſt Acid, which is united with them but ſuperficially, and in ſuch a manner as to retain all its virtue; but that if this ſame Acid be too intimately united with the Oil, ſo as to have no manifeſt power, but be in a manner deſtroyed, and converted as it were into a Neutral Salt, it will not then produce this effect.

A modern author * relates two experiments which agree very well with this opinion, and indeed confirm it. He mixed together Oil of Vitriol and Oil of Turpentine, with a view to imitate by art a bituminous matter; which, we know, is not at all, or at leaſt ſcarcely, ſoluble in water. Theſe two matters being united together produced a red, thick compound, which by evaporation became like a natural Bitumen.

The author obſerves, that when this mixture is juſt made it diſſolves in Alcohol; but that in ſome time it changes its nature, and communicates ſcarce any part of its ſubſtance to that ſolvent. Now whence can ſuch a difference ariſe, but from this, that when the mixture is new, the Acid is as yet but ſuperficially united with the Oil, and combines with it more and more intimately, as the mixture grows older.

The ſame author, having repeated the experiment with Spirit of Vitriol, obtained a compound which continued always very ſoluble in Spirit of Wine: becauſe Spirit of Vitriol being much weaker and more aqueous than Oil of Vitriol, was incapable of combining ſo cloſely with the Oil of Turpentine, as that concentrated Acid did in the former experiment. By the by, there is great reaſon to believe that the very intimate union of a mineral Acid with an oily matter is the true cauſe why Bitumens will not diſſolve in Spirit of Wine.

It ſeems therefore pretty probable, that the Acid which makes the Oil of Gummy matters ſoluble in water, and reduces it to a ſaponaceous ſtate, is ſo intimately united with that Oil, that it loſes its properties, and is in a manner converted into a Neutral Salt. Now we know that ſuch Salts

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* Mr. Eadows, in a little Engliſh book, entitled *The Modern Apothecary.*

are ſoluble in water, but are not ſo, for the moſt part, in Spirit of Wine.

If your Tinctures or Elixirs be not ſo ſtrong or ſo ſaturated as you deſire, you may by diſtillation abſtract part of the Spirit of Wine which they contain, and by that means give them ſuch a degree of thickneſs as you judge proper. But the Spirit of Wine thus drawn off conſtantly carries along with it a good deal of the aromatic principle. It is a truly *Aromatic Strong Water.* This Spirit of Wine alſo carries up with it a portion of thin Oil, which is ſo much the more conſiderable as the degree of heat employed is greater: and this is the reaſon why it becomes of a milky colour when mixed with water.

If you intend to make an Aromatic Strong Water only, you need not previouſly extract a Tincture from the vegetable ſubſtance with which you mean to prepare your water: you need only put it in a cucurbit, pour Spirit of Wine upon it, and diſtil with a gentle heat. By this means you will obtain a Spirit of Wine impregnated with all the odour of the plant.

CHAP. III.

Of TARTAR.

PROCESS I.

Tartar analyzed by diſtillation. The Spirit, Oil, and Alkaline Salt of Tartar.

INTO a ſtone retort, or a glaſs one coated with lute, put ſome white Tartar broken into ſmall bits, obſerving that one half, or at leaſt a full third, of the veſſel be left empty. Set your retort in a reverberating furnace. Fit on a large ballon, having a ſmall hole drilled in it; lute it exactly with fat lute, and ſecure the joint with a linen cloth ſmeared with lute made of quick-lime and the white of an egg. Apply at firſt an exceeding gentle heat, which will raiſe a limpid, ſouriſh, pungent water, having but little ſmell, and a bitteriſh taſte.

When this firſt phlegm ceaſes to come off, increaſe your fire a little, and make the degree of heat nearly equal to that of boiling water. A thin limpid Oil will riſe, accompanied with white vapours, and with a prodigious quantity of air, which will iſſue out with ſuch impetuoſity, that if you do not open the little hole in the receiver time enough to give it vent, it will burſt the veſſels with exploſion. An acid liquor will riſe at the ſame time. Continue the diſtillation, increaſing the heat by inſenſible degrees, and frequently unſtopping the little hole of the receiver, till the elaſtic vapours ceaſe to iſſue, and the oil to diſtil.

Then raiſe your fire more boldly. The acid Spirit will continue to riſe, and will be accompanied with a black, fetid, empyreumatic, ponderous, and very thick Oil. Urge the fire to the utmoſt extremity, ſo that the retort may be of a perfect red heat. This violent fire will raiſe a little Volatile Alkali, beſides a portion of Oil as thick as pitch. When the diſtillation is finiſhed, you will find in the retort a black, ſaline, charred matter, which grows hot when wetted, attracts the moiſture of the air, runs *per deliquium*, and hath all the properties of a Fixed Alkali.

This maſs, being expoſed to a naked fire in the open air, burns, conſumes, and is reduced to a white aſh, which is a fiery, cauſtic, Fixed Alkali.

OBSERVATIONS.

THE matters qualified to produce a ſpirituous liquor by fermentation, do not all contain the juſt and accurate proportion of Acid neceſſary to conſtitute an Ardent Spirit. Many of them, the juices of fruits for inſtance, and eſpecially that of the Grape, are replete with a ſuper-abundant quantity of Acid, more than concurs to form that product of fermentation. This ſuper-abundant Acid, combined with ſome of the Oil and earth contained in the fermented liquor, produces a ſort of Salt, which hangs for a while ſuſpended in that liquor, but after ſome time, when the Wine ſtands quiet in a cool place, ſeparates from it, and forms a ſtone-like incruſtation on the inſide of the vat in which the Wine is kept. This matter is called *Tartar*.

The Lees of Wine reſemble Tartar, in as much as they contain, and yield when analyzed, the ſame principles; but they differ from it in this, that they contain, moreover, a greater quantity of earth, of phlegm, and a little Ardent

Spirit, which are only mixed, but not united, with the tartarous Acid.

The reſidue, or ſort of extract, which remains in the cucurbit after Wine hath been deprived of its Ardent Spirit by diſtillation, hath alſo a great conformity with Tartar. It even contains that portion of Tartar which remained ſuſpended in the Wine at the time of its diſtillation: and accordingly this reſidue of Wine, being analyzed, yields the ſame principles with Tartar.

Hence we ſee, that liquors, which have undergone the ſpirituous fermentation, conſiſt of an Ardent Spirit and a Tartarous Acid ſuſpended in a certain quantity of Water.

In the analyſis of Tartar there are ſeveral things worthy of notice. The firſt is, the vaſt quantity of Air that this mixt body yields when it begins to be decompoſed. The chief difficulty attending its analyſis ariſes from this air; which iſſues out and exerts its elaſtic force with ſuch impetuoſity, that all the precautions above-mentioned are no more than neceſſary to prevent the burſting of the veſſels.

The ſingular nature of the thin limpid Oil, which riſes with this air, after the firſt acid phlegm, deſerves likewiſe our particular attention. This Oil is one of the moſt penetrating we know. Boerhaave, who diſtilled Tartar without having a vent-hole in his receiver, was obliged, in order to prevent its burſting, to apply it to his retort with a lute ſo weak that moſt of the elaſtic vapours might perſpire through it; and he obſerved, that, though the neck of his retort entered above five inches into the mouth of his receiver, and was luted on as cloſely as poſſible with ſuch a lute, yet this light Oil of Tartar conſtantly returned back again, as it were, and pervaded the ſubſtance of the lute, ſo that a good deal of it dropped in a diſh placed on the outſide on purpoſe to receive it. This Oil is probably rendered ſo active and ſubtile, only by having been exceedingly attenuated by the fermenting motion. This experiment is one of thoſe which ſufficiently prove the neceſſity of employing receivers having a ſmall vent-hole, that may be opened and ſhut as occaſion requires.

The laſt remark we ſhall make, on the productions of Tartar by diſtillation, relates to the *caput mortuum* found in the retort when the operation is finiſhed. This reſidue is very different from that which other vegetable matters afford: for, when they are decompoſed in cloſe veſſels, they leave nothing but a mere charred matter, in which no ſaline property appears, and from which no Fixed Alkali can be obtained,

tained, but by carrying their analyſis to the utmoſt; that is, by burning them in the open air. Tartar, on the contrary, only by being diſtilled in cloſe veſſels, without burning it afterwards in the open air, is changed into a ſubſtance which hath all the properties of a Fixed Alkali. This is probably owing to the Tartar's containing the principles requiſite to form a Fixed Alkali in a much greater quantity than they are to be found in any other ſubſtance. As Tartar thus alkalizated in cloſe veſſels ſtill contains much inflammable matter, it might be employed with advantage as a reducing flux, in ſeveral operations of metallurgy.

Of all the vegetable matters we know, calcined Tartar yields the greateſt quantity of Fixed Alkali; which is likewiſe very pure, and therefore much uſed in Chymiſtry.

Burnt Lees of Wine alſo afford a great quantity of Fixed Alkali, which is of the ſame nature with that of Tartar. This Salt is uſed in different trades, and particularly in Dying. The French Vinegar-makers collect quantities of theſe Lees, which they make up into cakes and dry: while it is in this ſtate they call it *Gravelle* or *Gravelée;* and *Cendre Gravelée* when it is burnt.

If the extract of Wine, which remains after the Spirit is drawn off, be gently evaporated to dryneſs, and that dry matter burnt like Tartar or *Gravelle*, it will make a ſort of *Cendre Gravelée* very rich in alkaline Salt.

PROCESS II.

The Depuration of Tartar. Cream and Cryſtals of Tartar.

REDUCE to a fine powder the Tartar you intend to purify, and boil it in twenty-five or thirty times as much water. Filter the boiling liquor through a flannel-bag, and then gently evaporate ſome part of it: there will ſoon form on its ſurface a ſaline cruſt, which is the *Cream of Tartar.* Let your liquor cool, and there will adhere to the ſides of the veſſel a great quantity of a cryſtallized ſaline matter, which is *Cryſtal of Tartar.*

OBSERVATIONS.

TARTAR, when taken out of the vats in which it forms, is mixed with a conſiderable quantity of earthy parts, which are not intimately united therewith, but adulterate it. This extraneous earth makes about two fifths of the whole weight of common Tartar; but white Tartar, which is the beſt, contains but about a third part of earth.

The method of refining Tartar, and freeing it from this adventitious earth, is very ſimple, as appears from the proceſs. Earthy matters, which are not intimately combined with an Acid in the form of a Neutral Salt, are not diſſoluble in water: for which reaſon the water, in which crude Tartar is boiled, diſſolves the ſaline part only, which paſſes with it through the filter; but doth not diſſolve the earth of the Tartar, becauſe that earth is not combined with the ſaline part, and ſo being only ſuſpended in the liquor remains on the filter.

The ſaline parts of the Tartar, though they are now ſeparated from the groſs earth with which they were mixed, are not yet perfectly pure. Theſe firſt Cryſtals of Tartar have a diſagreeable ruſſet colour, and are not tranſparent: this is owing to their being coated over, as it were, with a fatty matter, which alſo is foreign to their nature, and may be ſeparated from them without decompoſing them in the leaſt.

The cryſtals of Tartar are but ſeldom perfectly depurated in Chymical Laboratories; becauſe the operation doth not uſually ſucceed well on ſmall quantities: but there are manufactories which do it by the great, and ſupply the Chymiſts, as well as the ſeveral tradeſmen, with very fine and very pure Cryſtals of Tartar. Theſe manufactories are chiefly ſet up in the neighbourhood of Montpelier. Mr. Fiſes, a celebrated Profeſſor of Medicine, hath in the Memoirs of the Academy for 1725 deſcribed the operation as performed in one of theſe works. He tells us, that having ſeparated the earthy part from the Cryſtals of Tartar, by boiling and filtering, they diſſolve them again, and boil them in large caldrons, mixed with a white ſaponaceous earth, which cleanſes and whitens them to perfection.

The ſaponaceous earth is found near the works; but it is not the only one that may be employed for this purpoſe; ſince, as Mr. Fiſes obſerved, they have ſucceſſively made uſe of ſeveral different earths in that very work, and that the earth they now uſe hath not been long employed. There is reaſon to think that moſt ſaponaceous earths might anſwer the purpoſe of refining Cryſtal of Tartar: but one neceſſary condition is, that they be altogether indiſſoluble by Cryſtal of Tartar, which being acid diſſolves many ſorts of earth; for, if they have not this quality, they will form a Neutral Salt with the ſaline part of the Tartar, the nature of which they will entirely change, and convert it into ſoluble Tartar, as will appear by the experiments that follow.

CHAP. IV.

CRYSTAL *of* TARTAR *combined with ſeveral* SUBSTANCES.

PROCESS I.

Cryſtal of Tartar combined with Abſorbent Earths. Soluble Tartars.

BOIL an Abſorbent Earth, ſuch as Chalk, in a pan with water; and, when you perceive the Earth thoroughly divided, and equally diſtributed through the water, throw into a pan, from time to time, ſome pulverized Cryſtal of Tartar, which will excite a conſiderable effervеſcence. Continue thoſe projections, till you obſerve no effervеſcence excited thereby. All the Abſorbent Earth, which obſcured the tranſparency of the water, and gave it an opaque white colour, will gradually diſappear as the Cryſtal of Tartar combines with it; and when the combination is perfected, the liquor will be clear and limpid. Then filter it, and there will be left on the filter but a very ſmall quantity of earth. Evaporate all the filtered liquor with a gentle heat; and then ſet it in a cool place to ſhoot. Cryſtals will form therein, having the figure of flat quadrangular priſms, with almoſt always one, ſometimes two, of the angles of the priſm ſhaved down, as it were; and then the ſurfaces at each end are oblique, anſwering to thoſe depreſſed angles. Theſe cryſtals are a Neutral Salt, which readily diſſolves in water; a true *Soluble Tartar.*

OBSERVATIONS.

CRYSTAL of Tartar is a ſaline ſubſtance of a ſingular nature. Though it cryſtallizes like a Neutral Salt, yet it is not one: it hath only the form of one; its principal properties being thoſe of an Acid. Nevertheleſs it is not a pure Acid; for it is united with a certain quantity of Oil and of earth, which give it the property of cryſtallizing, and it is ſcarce diſſolvable in water. It is a middle ſubſtance between an Acid and a Neutral Salt. It is an Acid half-neutralized; on which account it is capable of acting like an Acid on all ſubſtances ſoluble by Acids, and ſo of being converted into a perfectly Neutral Salt by combining with them to the point of ſaturation.

In the experiments made to neutralize Cryſtal of Tartar, Fixed Alkaline Salts alone were formerly uſed. Meſſrs. Duhamel and Groſſe were the firſt who diſcovered that Abſorbent Earths might be ſubſtituted for Alkalis, and would produce nearly the ſame effects on Cryſtal of Tartar. The experiments made by theſe two Academicians in conjunction are circumſtantially related in two curious Memoirs on this ſubject, given in by them jointly, and printed with thoſe of the Academy for 1732 and 1733. From theſe Memoirs we took the proceſs here given, and ſhall alſo borrow from thence moſt of the remarks we are now going to make.

Stone-lime holds, as it were, the middle place between mere Abſorbent Earths and Fixed Alkalis. Now, ſeeing Cryſtal of Tartar may be converted into a Neutral Salt by either of theſe two ſubſtances, it follows, that lime ought to produce the ſame effect upon it. Accordingly Meſſrs. Duhamel and Groſſe found it to be ſo upon trial: having formed, with *Lac calcis* and Cryſtal of Tartar, a Neutral Salt perfectly like that which reſults from the union of that ſaline matter with Chalk. *Cremor calcis*, or that ſalino-terrene pellicle which forms on lime-water, produced the ſame effect: but, what is moſt ſingular is, that lime-water itſelf, though it be clear and limpid, and conſequently doth not ſeem to contain any earthy particles, produced nevertheleſs a great efferveſcence with Cryſtal of Tartar, and neutralized it as perfectly as *Cremor calcis*, or water ever ſo much impregnated with Chalk. This ariſes from hence, that a great quantity of the ſalino-terrene matter, which forms the *Cremor calcis* is diſſolved in the lime-water.

Though lime-water neutralizes Cryſtal of Tartar as perfectly as Chalk does, and though the Cryſtals of ſoluble Tartar, or neutralized Tartar, thereby produced, be like thoſe which have Chalk for their baſis, yet Meſſrs. Duhamel and Groſſe obſerved ſome differences, worthy of notice, between the phenomena accompanying the production of theſe two Neutral Salts, which reſemble each other ſo much that they ſeem but one and the ſame ſpecies of Salt. The principal difference conſiſts in this, that the water containing the Tartar neutralized by Chalk is very limpid, and leaves but a very ſmall quantity of earth on the filter; whereas the lime-water, with which Tartar hath been neutralized, leaves on the filter a conſiderable quantity of earth.

This muſt appear the more ſurpriſing, that the water replete with Chalk was, before its union with the Cryſtal of Tartar, turbid and opaque; whereas the Lime-water was at firſt clear and limpid. Meſſrs. Duhamel and Groſſe ſuſpect this to ariſe from hence, that the effervescence excited, while the Cryſtal of Tartar diſſolves the matter contained in lime-water, is greater than that which is produced by its union with Chalk ſuſpended in water.

" If we conſider," ſay they, " that in a great effervescence " a conſiderable quantity of the acid Spirit is evaporated, " we ſhall eaſily perceive, that, the more of that Spirit " eſcapes, the more of the earth of the Tartar will be precipitated. Now, as the effervescence with lime-water is " more conſiderable, and as there is leſs alkaline earth to " check, as it were, and reſtrain the Acid, than in the experiment with Chalk, a greater quantity of the acid Spirit " may eſcape; which being entirely loſt will cauſe more " earth to precipitate in this caſe than in the other, where " the Acid is all at once attracted by a great deal of alkaline earth: and accordingly this was the reaſon that our " Tartar diſſolved by Chalk depoſited, in cryſtallizing, a grey " earth, which was ſcarce perceivable in the experiment " made with Lime-water.

" Yet perhaps, ſay they, an Acid, which we ſuſpect to " be contained in lime, may have partly occaſioned the precipitation of this earth." The exiſtence of this Acid, which theſe gentlemen at that time only ſuſpected, hath been ſince demonſtrated by ſeveral experiments, and particularly by thoſe which Mr. Malouin hath publiſhed. This Acid is the Vitriolic, which, in combination with ſome of the earth of the lime, forms a ſort of Selenitic Salt; which adds greatly to the probability of Meſſrs. Duhamel and Groſſe's laſt conjecture. I ſhall now explain how I conceive the Vitriolic Acid in lime may occaſion the copious precipitate which falls in lime-water, when Cryſtal of Tartar is neutralized by it.

The quantity of Vitriolic Acid contained in lime is very inconſiderable; ſo that to convert it into a Neutral Salt requires its intimate union with a very ſmall quantity of the earthy and abſorbent parts. Hence it comes to paſs, that, when water is poured upon quick-lime, in order to make the Lime-water, it in ſome ſort divides the lime into two parts.

All the particles of Abſorbent Earth, which had not contracted an union with the Acid, are at firſt barely ſuſpended in the liquor, the tranſparency of which they deſtroy, giving it an opaque white colour; and this is what makes the *Lac calcis:* but they ſoon ſeparate from it, and fall to the bottom, in the form of a precipitate; becauſe they are not ſoluble in water. By this precipitation the liquor becomes limpid, and remains impregnated only with ſuch of the earthy parts as are united with the Vitriolic Acid, in the form of a kind of Neutral Salt, and have by that union acquired ſolubility. But the Vitriolic Acid finding many more Abſorbent parts in the lime than were neceſſary to neutralize it, in a manner over-doſed itſelf with earthy parts, and thereby exceeded the bounds of a perfect Neutrality.

On the other hand, it hath been ſhewn, that Cryſtal of Tartar is an imperfect Neutral Salt. Now theſe two Salts, which are neither of them perfectly Neutral, differ from a perfectly Neutral Salt by properties directly oppoſite to each other; ſeeing the Selenitic matter in Lime exceeds in its abſorbent or alkaline quality, and Cryſtal of Tartar exceeds, on the contrary, in acidity.

What muſt be the conſequence, therefore, of mixing theſe two ſaline matters together? The ſame as when an Acid is mixed with a Fixed Alkali; that is, the Salt which exceeds in acidity will combine with the ſuper-abundant alkaline earth of the Selenitic Salt; ſo that theſe two ſaline matters will both become perfectly Neutral Salts. Yet theſe two Neutral Salts have not the ſame degree of ſolubility in water. The neutralized Cryſtal of Tartar diſſolves very readily in water, and is for that reaſon called Soluble Tartar: the Selenitic Salt, on the contrary, is hardly diſſolvable in it at all. Now it is a rule that, when two Salts of this nature meet together, the moſt ſoluble always remains united with the water, excluſive of the other, which is forced to precipitate. This I imagine to be what happens in the preſent caſe; and the precipitate which we ſee fall, in the lime-water employed to neutralize Cryſtal of Tartar, ſeems to me to be no other than the Selenitic Salt of the Lime; which, being leſs ſoluble than the neutralized Tartar, gives place to it, and ſeparates from the liquor.

Indeed we cannot, in my opinion, account for the precipitate under conſideration, any other way, than by ſuppoſing it to be a portion either of the earth of the Cryſtal of Tartar, or a portion of the Lime. Now, either of theſe earths is diſſolvable by Acids; whereas the precipitate in queſtion, according to the obſervations of Meſſrs. Duhamel and Groſſe, is not ſo: and this ought to be the caſe, if the precipitate be nothing but the ſelenitic Salt of the Lime, which being a Neutralized Salt, partly conſtituted by the moſt powerful of all the Acids, muſt be unalterable by any Acid whatever.

Meſſrs. Duhamel and Groſſe made a great many experiments on the combinations of Cryſtal of Tartar with different ſorts of earths. The reſult of the whole is, that there are ſome earths which this Acid diſſolves, and which contract ſuch an union with Cryſtal of Tartar, that they not only change its external character, that is, its tendency to cryſtallize, and its indiſſolubleneſs in cold water, but alſo entirely alter its taſte and other qualities. In a word, thoſe earths produce on this Salt all the effects of alkaline Salts. Theſe earths are ſuch as are called Abſorbent Earths; ſtone-lime, animal-lime, cretaceous earths, a portion of calcined gypſum, and of potaſh; in ſhort, all ſuch as diſtilled vinegar is capable of diſſolving: this is the mark by which thoſe earths, which are qualified to neutralize Cryſtal of Tartar, and to render it ſoluble, may be diſtinguiſhed.

Meſſrs. Duhamel and Groſſe found alſo upon trial, that there are other earths, on the contrary, which are, in a manner, inacceſſible to the Acid of Cryſtal of Tartar; that they take up, indeed, the groſſeſt and redundant Oil of the Tartar, but without affecting its ſaline part at all: and if theſe earths are ever obſerved to form any union with the Cryſtals of Tartar, as happens in the refineries near Montpelier, that union is only ſuperficial, not intimate; and therefore it alters none of the characters of the Salt. Among theſe earths are the clayey, bolar, ſandy earths, and others of that kind. Hence Meſſrs. Duhamel and Groſſe conclude, that theſe are the earths which ought to be employed in the purification and whitening of Cryſtal of Tartar. Vinegar is here alſo the teſt by which it may be known whether an earth intended for this purpoſe be fit for it: for you may be ſure that it will form no union with Cryſtal of Tartar, if the Acid of Vinegar be incapable of diſſolving it.

PROCESS II.

Cryſtal of Tartar combined with Fixed Alkalis. The Vegetable Salt. Saignette's Salt. The Decompoſition of Soluble Tartars.

IN eight parts of water diſſolve one part of a very pure alkaline Salt, perfectly freed from the phlogiſton by calcination. Heat this lixivium in a ſtone pan ſet on a ſand-bath, and from time to time throw into it a little powdered Cream or Cryſtal of Tartar. Each projection will excite a great effervеſcence, attended with many bubbles, which will riſe to a conſiderable height one over the other. Stir the liquor when the effervеſcence ceaſes, and you will ſee it begin again.

When no effervеſcence appears upon ſtirring the liquor, add a little more Cream of Tartar, and the ſame phenomena will be renewed. Go on thus till you have obtained the point of perfect ſaturation.

Then filter your liquor. If the Alkali you made uſe of was the Salt of Soda, evaporate your liquor quickly to a pellicle, and there will ſhoot in it cryſtals of nine ſides, reſembling a coffin; the bottom part thereof being concave, and ſtreaked with a great many parallel lines; and this is *Saignette's Salt*. If you have employed any other Alkali but Soda, or the baſis of Sea-ſalt, evaporate your liquor ſlowly to the conſiſtence of a ſyrup: let it ſtand quiet, and there will form in it cryſtals having the figure of flatted parallelopipeds; and this is the *Vegetable Salt*, or *Tartarized Tartar*.

OBSERVATIONS.

SEEING pure Abſorbent Earths are capable of neutralizing Cryſtal of Tartar, and converting it into Soluble Tartar, there is ſtill more reaſon to expect that Fixed Alkalis ſhould poſſeſs the ſame property, as they have a much greater affinity with Acids: and accordingly Cryſtal of Tartar always forms, with every ſpecies of theſe ſalts, a Neutral Salt which is a Soluble Tartar.

A Soluble Tartar, formed by the union of Cryſtal of Tartar with Tartar converted into an Alkali by fire, hath been long uſed in medicine as a gentle ſaponaceous purgative, known by the names of *Tartarized Tartar*, or the *Vegetable Salt*. But the Soluble Tartar, prepared by combining Cryſtal of Tartar with the Alkali of Soda, which, as we remarked before, is analogous to the baſis of Sea-ſalt, and different from all other Alkalis, was not well known to Chymiſts till the year 1731, when M. Boulduc publiſhed the preparation in a Memoir printed in the Academy's collection for that year [*].

Not but that it was very much uſed before that time: for it had been for ſeveral years in high reputation, and preſcribed inſtead of Tartarized Tartar, which became almoſt quite neglected. But M. Saignette, a phyſician of Rochelle, who was the firſt inventor and vender of this Salt, did not publiſh the preparation of it, which he kept as a ſecret: and this probably contributed not a little to the great eſteem which this medicine had acquired; for men are naturally inclined to put a much greater value on ſecrets, than on what is univerſally known. He gave it the name of *Sal Polychreſtum;* and the public called it alſo *Saignette's Salt*, and *Rochelle Salt*. Since the diſcoveries of M. Geoffroy and M. Boulduc were publiſhed, the method of preparing this Salt hath been no ſecret; it was deſcribed in Diſpenſatories, and every apothecary hath made it ever ſince.

Saignette's Salt, as well as every other Soluble Tartar, melts when laid on live coals, boils up, emits ſmoke, and leaves a black charred matter behind. This reſemblance of Saignette's Salt to Tartarized Tartar, joined to the ſmell of the vapour which exhaled in burning it, and is the ſame with that of Tartar, were the firſt notices that led M. Boulduc to ſuppoſe this Salt to be a ſoluble Tartar. On examining the alkaline coal produced by the calcination, and comparing it with that left by Tartarized Tartar, he perceived there was ſome difference between them. At laſt his friend, M. Groſſe, having adviſed him, as he tells us in his Memoir, to combine Cryſtal of Tartar with the Salt of Soda, and to examine the new Salt that would reſult from their union, M. Boulduc immediately ſuſpected that it muſt produce a ſpecies of Soluble Tartar, which might poſſibly prove to be the Salt in queſtion. Nor was he miſtaken in his conjecture: for with theſe two ſaline ſubſtances he actually compoſed a Salt perfectly like Saignette's.

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[*] It could not be any longer concealed; for M. Geoffroy having made ſome experiments on the ſame ſubject, without knowing any thing of what M. Boulduc had done, likewiſe diſcovered it. See the Hiſtory of the Academy for 1731, p. 35.

Under the head of Borax we remarked that it contains an Alkali like the baſis of Sea-ſalt. This Alkali is not perfectly neutralized by the ſedative Salt, which is alſo contained in Borax: for its alkaline properties are ſo perceptible as to have led ſome Chymiſts to think that Borax was only an Alkali of a particular kind. This induced M. le Fevre, a Phyſician at Uzes, and one of the Academy's correſpondents, to combine Cryſtal of Tartar with Borax, and to examine the reſult. He communicated to the Academy his experiments on this ſubject; by which he found that the combination of theſe two ſaline matters forms a Soluble Tartar, but greatly different from Saignette's Salt; eſpecially in that it doth not cryſtallize, but remains in the form of a gummy matter, and retains all the acidity natural to pure Cream or Cryſtal of Tartar: a circumſtance which is very remarkable.

Mr. Lemery had the curioſity to repeat M. le Fevre's experiment, and found that this ſingular Soluble Tartar had the properties aſcribed to it by the inventor. The proceſs he recommends for making the experiment with ſucceſs is as follows:

" Take four ounces of Cryſtal of Tartar finely pulverized, " and two ounces of Borax carefully powdered, and put " theſe two Salts into a flint-glaſs body. Pour on them two " ounces of water, and ſet the cucurbit into a ſand-bath. " Warm it with a gentle fire, and then increaſe the heat ſo " as to make the liquor boil for a quarter of an hour; which " will produce a perfect diſſolution of the Cream of Tartar " and Borax. After the diſſolution of theſe two Salts united together, the liquor will remain clear and limpid, " though the boiling hath diſſipated a good deal of it. If " the liquor be ſtill further evaporated, the remainder will " have the conſiſtence of Honey, or Turpentine: and, if " the evaporation be carried ſtill farther, with a gentle heat, " the matter remaining will in colour reſemble the gum of " a plumb-tree, and yield to preſſure as that does; and, if " it be expoſed to the air in a damp place, it will grow moiſt " and run, almoſt like Salt of Tartar:" a new and ſingular property, which belongs neither to Borax nor to Cryſtal of Tartar, when they are not combined together.

All Soluble Tartars are eaſily decompounded, by means of a certain degree of heat. They yield in the diſtillation the ſame principles as Tartar; and the Alkali that remains, when they are perfectly calcined, conſiſts of that which the Tartar naturally affords, and of the alkaline matter with which it was converted into a Neutral Salt.

Theſe Neutral Salts, reſulting from the union of Cryſtal of Tartar with any alkaline matter, are alſo decompounded by all the Acids, even by vinegar, which nevertheleſs is an Oily Vegetable Acid, and conſequently of the ſame kind with Cryſtal of Tartar. The reaſon of this is that the Acid of Vinegar, though blunted by much phlegm and oil, muſt be conſidered as a free and pure Acid, when compared with Cryſtal of Tartar; which is ſtill more embarraſſed with heterogeneous matters, ſo as to be a ſemi-neutral Salt.

When Soluble Tartar is decompounded by an Acid, the Cryſtal of Tartar, which helped to conſtitute the Neutral Salt, is then wholly recovered. This ſaline matter, being ſeparated from that which rendered it ſoluble in water, ceaſes now to be ſo, and for that reaſon precipitates to the bottom of the liquor.

The Neutral Salts, reſulting from the decompoſition of Soluble Tartar by an Acid, differ according to the Acid made uſe of. From Saignette's Salt decompounded by the Vitriolic Acid M. Boulduc obtained a true Glauber's Salt, and a precipitate of Cryſtal of Tartar: and this he juſtly adduces as a demonſtrative proof, that Saignette's Salt is no other than Cryſtal of Tartar neutralized by a Fixed Alkali analogous to the baſis of Sea-ſalt.

Though all Soluble Tartars may be decompounded by Acids, as hath juſt been ſaid, yet they do not all forſake their baſes with equal facility. Meſſrs. Duhamel and Groſſe found that, in this reſpect, they obſerve the following order, beginning with thoſe which afford the readieſt and moſt copious precipitate: viz. Soluble Tartar made 1. with Potaſh; 2. with Chalk; 3. with uncalcined Oyſter-ſhells; 4. with Stone-Lime; 5. with calcined Oyſter-ſhells; 6. with Salt of Tartar; 7. with Salt of Soda; 8. and laſtly, Tartar made ſoluble with Borax is not precipitated by diſtilled vinegar.

It is not eaſy to account for this difference between Soluble Tartars. If the Salt of Soda were more alkaline than Salt of Tartar, and Borax more alkaline than the Salt of Soda, it might be conjectured that the more alkaline the matters are with which Cryſtal of Tartar is neutralized, the cloſer is the union it contracts with them; ſince it is plain, from what hath been ſaid on this ſubject, that though Soluble Tartars, which have for their baſis Abſorbent Earths only, not converted into Lime, are more eaſily decompounded than thoſe which are rendered ſoluble by Limes; and theſe again more eaſily than thoſe which have a Fixed Alkali for their baſis. But, on the contrary, the Salt of Soda is leſs alkaline than Salt of Tartar, and Borax ſtill leſs than the Salt of Soda.

PROCESS III.

Cryſtal of Tartar combined with Iron. Chalybeated Tartar. Tincture of Steel with Tartar. Soluble Chalybeated Tartar.

MIX four ounces of Iron, in filings, with one pound of white Tartar, finely pulverized. Boil the mixture in about twelve times as much water as you took of Tartar. When the ſaline part of the Tartar is diſſolved, filter the liquor boiling-hot through a flannel bag, and then ſet it in a cool place. In a very little time cryſtals of a ruſſet colour will ſhoot therein. Decant the liquor from theſe cryſtals; evaporate it to a pellicle, and ſet it again to cryſtallize. Go on in this manner till it will ſhoot no more. Collect all the Salt you have thus obtained, and keep it under the name of *Chalybeated Tartar.*

To make the Tincture of Steel with Tartar, mix together ſix ounces of clean Iron filings, and one pound of white Tartar in powder. Put this mixture into a large iron kettle, and pour thereon as much rain-water as will moiſten it.

Make a paſte of this matter, and leave it thus in a maſs for twenty-four hours. Then pour on it twelve pounds of rain-water, and boil the whole for twelve hours at leaſt, ſtirring the mixture frequently, and adding from time to time ſome hot water, to ſupply the place of what evaporates. When you have thus boiled the liquor, let it ſtand quiet for ſome time, and then pour it off from the ſediment at bottom. Filter, and evaporate to the conſiſtence of a ſyrup; and you have the *Tincture of Mars with Tartar.* The Diſpenſatories generally order an ounce of rectified Spirit of Wine to be poured on this Tincture, in order to preſerve it, and to keep it from growing mouldy, as it is very apt to do.

Soluble Chalybeated Tartar is prepared by mixing four ounces of Tartarized Tartar, with one pound of the Tincture of Mars with Tartar, and evaporating them together in an iron veſſel to dryneſs; after which it is kept in a well ſtopped phial, to prevent its growing moiſt in the air.

OBSERVATIONS.

THE three preparations of this proceſs are medicines very well known and much uſed. There is even reaſon to think that thoſe, who firſt thought of combining Tartar in this manner with Iron, had it in their view to prepare compoſitions uſeful in medicine, rather than merely to produce new combinations for the improvement of Chymiſtry. Indeed, were we to conſider only the account here given of the manner in which theſe three compoſitions are made, we ſhould be inclined to think Cryſtal of Tartar incapable of diſſolving Iron ſo thoroughly and radically, that, from the union of theſe two ſubſtances, a Neutral Metallic Salt ſhould ariſe, a Tartar neutralized and made ſoluble by Iron. For it is very certain that the firſt of theſe preparations, which is called Chalybeated Tartar, is nothing but the ſaline part of Tartar diſſolved by boiling water, and then precipitated and cryſtallized along with particles of iron, that are reduced, at moſt, into a ruſt, or a *crocus* only, but have contracted no union with the cryſtal of Tartar, which remains as Acid and as indiſſoluble after this preparation as before. Accordingly it is called only *Chalybeated Tartar*, and not *Soluble Chalybeated Tartar:* and, as this latter name hath been given only to the Tartarized Tincture of Mars compounded with Tartarized Tartar; that is, with Tartar rendered ſoluble by a Fixed Alkali, and not by Iron; there is reaſon to preſume, that the Tincture of Mars alone was not thought worthy of being called a Soluble Chalybeated Tartar; but that the name, importing *Tartar rendered ſoluble by Mars*, belongs to that Tincture only when compounded with a true Soluble Tartar.

It is nevertheleſs very certain, that the Tincture of Mars made with Tartar contains a true Soluble Chalybeated Tartar; that is, a Neutral Salt conſiſting of Cryſtal of Tartar united with Iron, and rendered ſoluble by that union. The long boiling, neceſſary to prepare this Tincture, gives the Acid of Tartar time to diſſolve the Iron radically, and to unite very cloſely therewith: but this is not the caſe in the preparation of Chalybeated Tartar; to make which the Tartar is boiled in water only as long as is neceſſary for the diſſolution of its ſaline parts; that is, about a quarter or half an hour; in which ſpace the Acid of the Tartar can ſcarce begin to act on the ſurface of the Iron: for Acids have not ſo quick an effect on metals, as on Alkalis and Abſorbent Earths. Metallic ſubſtances, being vaſtly more compact, are not near ſo ſoon diſſolved by Acids, and eſpecially by vegetable Acids, weakened with heterogeneous matters, as the Acid of Tartar is.

I thought the diſſolution of Iron by Tartar a point of ſufficient importance to deſerve a little more attention than hath commonly been given to it; and for that reaſon reſolved to examine, and trace with care, the phenomena obſervable in this operation.

As the crude Tartar, employed in making the Tartarized Tincture of Mars, is replete with many oily and earthy parts, which cannot but obſtruct the diſſolution of the Iron, and prevent our ſeeing clearly how that diſſolution is carried on, I thought it better to make uſe of Cream, or Cryſtals, of Tartar, which, being pure and freed from all thoſe heterogeneous parts, diſſolve in boiling water without prejudicing its tranſparency.

I therefore pulverized Cream of Tartar, and diſſolved as much thereof in boiling water as it would take up. This ſolution I poured boiling hot into a matraſs, at the bottom of which I laid ſome fine iron wire cut into ſmall pieces. I ſet the matraſs in a ſand-bath; and having heated it ſo as to make the liquor boil, I obſerved that, the inſtant before it boiled, the liquor began to act very perceptibly upon the Iron, in the ſame manner as other Acids act upon metallic ſubſtances; that is, there appeared on the ſurfaces of the little bits of Iron ſmall bubbles, which immediately roſe to the ſurface of the liquor, and ſucceeded each other ſo faſt, that they formed lines, or jets, ſeemingly continued from the ſurface of the Iron to the ſurface of the liquor, which, little by little, acquired a faint tinge of yellow.

When the liquor was heated ſo as to boil, the diſſolution ſtill went on, but much more briſkly, and the liquor acquired a deeper colour. After boiling about an hour, the liquor, which at firſt was very clear, became turbid, and of an opaque white; which made me think, that ſome of the Cream of Tartar, diſſolved therein, began to precipitate.

I let the whole boil ſome time longer, and the white precipitate becoming more conſiderable, I reſolved to filter the liquor, which paſſed through clear, and tinged with a greeniſh yellow. There remained on the filter a whitiſh ſediment, which I found to be true Cream of Tartar. The filtered liquor taſted much like a ſolution of Copperas. I evaporated it in a glaſs baſon, ſet in a ſand-heat, but no pellicle appeared; which made me conclude that it would produce no cryſtals: accordingly, having taken ſome of it out of the baſon, when it was conſiderably reduced by evaporation, and ſet it in a cool place, no cryſtal ſhot in it.

The reſt of the liquor I evaporated to dryneſs: it left a blackiſh brown reſiduum, which had the ſame taſte with the liquor before evaporation, but much ſtronger. This reſiduum melts very readily in the mouth, without leaving on the tongue the leaſt gritty particle. Being expoſed very dry to the air, it grows moiſt, and runs into a liquor in a very little time. It diſſolves eaſily and readily in a very ſmall quantity of cold water. This ſolution being mixed with Fixed Alkalis, in various proportions, doth not grow turbid, nor drops any precipitate; but with a decoction of galls it makes ink. Acids give it a much clearer colour, and at firſt produce no precipitation; but, in a quarter of an hour, there appears a precipitate much of the ſame colour with the ſolution. This precipitate is no other than Cream of Tartar, tinged of a ruſſet colour by the liquor, which grows turbid, and a little whitiſh, when the precipitate begins to form.

Theſe experiments, and the circumſtances attending them, will not allow us to doubt the truth of what I advanced concerning the Tincture of Mars made with Tartar, *viz.* that it is nothing but Cryſtal of Tartar by which Iron is diſſolved, and which is rendered ſoluble by that metal. We ſee at the very firſt that Cryſtal of Tartar acts upon Iron, juſt as other Acids do. Indeed this metallic ſolution is not precipitated by Alkalis: but we know that Alkalis poſſeſs the property of diſſolving Iron, eſpecially when the metal is previouſly divided by an Acid; ſo that there is reaſon to think this may be the caſe, when an Alkali is mixed with our Soluble Chalybeated Tartar.

As this Soluble Tartar is a ſaponaceous and oily Salt, it is alſo poſſible that it may be diſſolved entirely by the Alkali, without ſuffering any decompoſition; eſpecially as Alkalis decompound Neutral Metallic Salts, by means only of the ſtronger affinity which they have with the Acids, than with the Metals, of which thoſe Salts are compounded. Now, as our Soluble Chalybeated Tartar is compounded of that Metal which the Alkali diſſolves with the greateſt eaſe, and of that Acid with which it hath the leaſt affinity of any, it is very poſſible that it may not have a greater affinity with the Acid than with the metallic baſis of this Salt, and ſo be uncapable of decompounding it. However, as this Soluble Chalybeated Tartar makes a black liquor with a decoction of Galls, and as nothing but Iron diſſolved by an Acid hath that property, it may be ſafely concluded, that this Salt really conſiſts of Iron diſſolved by the Acid of Tartar.

The precipitate which a ſolution of this Salt lets fall, on the addition of an Acid, is another proof that it conſiſts of theſe two principles: for this precipitate can be no other than the Tartarous Acid, which, being the weakeſt of all Acids, is ſeparated from the Iron by the Acid added to the ſolution; which Acid unites with the Martial baſis, and forms another Neutral Metallic Salt, according to the Acid employed. Laſtly, the great ſolubility of the deſiccated reſiduum of the Tincture of Mars, made with Tartar, is a very ſtrong and deciſive proof, that this reſiduum is no other than Iron diſſolved by the Acid of Tartar: for what elſe can it be? Nothing but Iron and Cryſtal of Tartar is made uſe of in the operation; and neither of theſe two ſubſtances ſingly is ſo ſoluble as this new body.

We know, moreover, that Cryſtal of Tartar, which itſelf is indiſſoluble, forms a Soluble Tartar when combined with pure Abſorbent Earths, though theſe matters be ſtill more indiſſoluble than it, or rather, are not ſoluble at all. Hence it is very natural to conclude, that our reſiduum is a Tartar rendered ſoluble by Iron. This Chalybeated Tartar is even more ſoluble than any other ſort of Soluble Tartar; for it very readily grows moiſt in the air, and runs wholly into a liquid; on which account it is not ſuſceptible of cryſtallization.

I return to one of the circumſtances attending my experiment, which it is proper I ſhould account for; though I have hitherto only mentioned it, without more particular notice, that I might not break the connection between facts, and the conſequences reſulting from them. The circumſtance I mean is the precipitation of the Cream of Tartar diſſolved in the liquor, which, I ſaid, happens when the ſaline ſolution hath boiled upon the Iron about an hour. This precipitation of the Cream of Tartar may be partly occaſioned by the evaporation of the water in which it is diſſolved: for the water having taken up, as was ſaid, as much Cream of Tartar as it was capable of diſſolving, when the quantity of water comes to be leſſened, a proportional quantity of Cream of Tartar muſt precipitate.

But ſome other cauſe muſt alſo contribute to produce this precipitation: for, as I boiled my liquor in a matraſs, the evaporation of the liquor could not be conſiderable, and yet the precipitate was very copious. Moreover, I repleniſhed the matraſs with much more water than was neceſſary to replace

place what had evaporated; yet I could not re-diſſolve the precipitated Cream of Tartar, nor even ſenſibly leſſen its quantity.

The true cauſe of this effect I take to be as follows. When the ſolution of Cream of Tartar hath boiled for ſome time upon the Iron, and diſſolved a certain quantity thereof, a proportional quantity of Soluble Chalybeated Tartar is formed. Now as this Salt is much more ſoluble in water than Cream of Tartar, and as water always takes up the more ſoluble Salts, preferably to the leſs ſoluble, it is not ſurpriſing that Cream of Tartar, being one of thoſe ſaline ſubſtances which diſſolve with the greateſt difficulty, ſhould on this occaſion ſeparate from the liquor, and precipitate; yielding its place to a Salt which hath a much greater affinity with water.

Hence it appears, that to re-diſſolve the Cream of Tartar, and render it capable of continuing to diſſolve the Iron as efficaciouſly as before, it is not ſufficient that freſh water be added; but the ſolution of the Soluble Chalybeated Tartar already formed muſt be entirely decanted, and freſh water poured on the reſidue; and then this water, not being impregnated with any Soluble Chalybeated Tartar, will be capable of re-diſſolving the Cream of Tartar, and every thing will go on as at the beginning of the operation, till the Cream of Tartar come to precipitate again, for the ſame reaſon as before, and make a repetition of the ſame management neceſſary. The liquor is far from being ſaturated with Soluble Chalybeated Tartar, when the precipitation of the Cream of Tartar renders it neceſſary to decant it: ſo that the water muſt be often renewed, if you carry the operation to the utmoſt; and then all theſe ſolutions muſt be added together, and evaporated, either to dryneſs, if you deſire to have the ſalt in a dry form, or to any other degree you think proper.

This method I followed at firſt: but as it is exceeding long and tedious, though perhaps the beſt; and as I wanted to have a moderate quantity of Soluble Chalybeated Tartar, with leſs trouble, and in leſs time, if poſſible, I reſolved to try whether or no Cream of Tartar, though ſeparated from the liquor and un-diſſolved, were ſtill capable of acting on the Iron with ſuch efficacy as to diſſolve it. I therefore continued to boil the tartarous ſolution on the filings of Iron, notwithſtanding the precipitation of the Cream of Tartar, taking care only to add freſh water from time to time, as directed in the proceſs for the Tartarized Tincture of Mars, to replace what evaporated; and I obſerved that, in fact, the Cream of Tartar, though not perfectly diſſolved, but only divided and agitated by the motion of boiling, ſtill continued to act upon the Iron; ſo that the liquor, after boiling ſeven or eight hours, was ſo impregnated as to yield by evaporation a reaſonable quantity, in bulk, of Salt in a dry form.

PROCESS IV.

Cryſtal of Tartar combined with the reguline Part of Antimony. Stibiated or Emetic Tartar.

PULVERIZE and mix together equal parts of the Glaſs and of the Liver of Antimony. Put this mixture, with the ſame quantity of pulverized Cream of Tartar, into a veſſel capable of containing as much water as will diſſolve the Cream of Tartar. Boil the whole for twelve hours, from time to time adding warm water, to replace what is diſſipated by evaporation. Having thus boiled your liquor, filter it while boiling hot; evaporate to dryneſs; and you will have a ſaline matter which is *Emetic Tartar*.

OBSERVATIONS.

THE Glaſs and Liver of Antimony are no other, as was ſaid in its place, than the metallic earth of Antimony ſeparated from the redundant Sulphur of that mineral; but ſtill retaining ſuch a quantity of phlogiſton as to poſſeſs, excepting its metalline colour, nearly the ſame properties with Regulus of Antimony, and eſpecially its emetic quality, and its ſolubility in Acids. Indeed theſe two preparations ſeem to have more of an emetic quality than the Regulus itſelf, and therefore are employed preferably to all others in the preparation of Emetic Tartar.

It is not yet aſcertained in which of the principles of Antimony its emetic virtue reſides. We are ſure, however, that it cannot be aſcribed to its earthy part: for the calx of Antimony, when entirely deprived of all phlogiſton, is not emetic, nor even purgative; as is evident from the effects of Diaphoretic Antimony and the Pearly Matter.

Some authors think Antimony contains an arſenical principle, to which they impute its emetic quality; nor is their opinion altogether void of probability. For this arſenical part ſeems to be indicated by ſeveral of the properties of Antimony,

timony, and particularly by its affinities with other metallic ſubſtances, in which it very nearly reſembles Arſenic. But this doth not amount to a poſitive proof: for we can draw nothing but probable conjectures, at moſt, from ſuch analogies.

Other Chymiſts think the emetic virtue of Antimony depends on the union of its metallic earth with its phlogiſton. This opinion ſeems to me much more probable than the other: for by only recombining a phlogiſton with the earth of Antimony, deprived by calcination of all its emetic virtue, that virtue is perfectly reſtored, and the Regulus thus revivified is no leſs emetic than that which never underwent calcination.

However this be, it is certain that Cream of Tartar acquires an emetic quality, not by barely uniting with one of the principles of Antimony, but by diſſolving entirely the reguline, or ſemi-reguline, part thereof; and that its emetic quality is ſo much the ſtronger, the more of that ſubſtance it hath diſſolved. This is the reſult of ſeveral experiments made on the ſubject by Mr. Geoffroy.

That gentleman collected ſeveral parcels of Emetic Tartar, having different degrees of ſtrength. " I employed," ſays he *, " an ounce of each of thoſe Emetic Tartars: I rubbed " them ſeparately with an equal weight, or ſomething more, " of a black flux, made of two parts of red Tartar, and one " part of Nitre calcined together. Theſe mixtures I put " into different crucibles, formed like inverted cones: I kept " them in a melting heat till the Salts in fuſion ſunk, and " appeared like a ſmooth oil at the bottom of each crucible. " I then let the fire go out, broke the crucibles when cold, " and found the reſuſcitated Regulus in a maſs at bottom.

" Out of one ounce of the weakeſt Emetic Tartars I ob- " tained from thirty grains to one dram eighteen grains of " Regulus. From one ounce of ſuch as were of a middling " ſtrength I got one dram and an half; and the moſt violent " yielded me two drams and ten grains.

" The power, therefore, of the ſtrongeſt Emetic Tartars," continues he, " depends on the quantity of Regulus of An- " timony diſſolved by the Cream of Tartar, and the nearer " the preparations of Antimony, on which the ſolution of " Cream of Tartar is boiled, are to the form of a Regulus " or a Glaſs, the more violent is the Emetic Tartar; becauſe " the Vegetable Acid of the Tartar acts then more imme-

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[*] Memoirs of the Academy for 1734, p. 421.

" diately upon the Emetic part of the Antimony, and diſ-
" ſolves more of it."

Mr. Geoffroy found upon trial, that Cream of Tartar boiled for a due time on Crude Antimony, doth indeed diſſolve a little of the reguline part thereof; but that the quantity of Regulus diſſolved thereby is ſo very ſmall, that the Emetic Tartar produced is extremely weak. The groſs Sulphur, in this caſe, hinders the Cream of Tartar from acting on the reguline part with ſo much efficacy, as when the Antimony is properly prepared by freeing it entirely from its redundant Sulphur.

Nothing can be added to what Mr. Geoffroy hath ſaid on this ſubject. His experiments are deciſive, and ſet the truth he intended to prove in the cleareſt light.

Mr. Hoffman affirms, that Emetic Tartar loſes part of its virtue by being boiled too long. A very able Chymiſt goes ſo far as to ſay, that Tartar ought not to boil above ſix or ſeven minutes with prepared Antimony; becauſe longer boiling deſtroys part of its Emetic quality. Can this ariſe from hence, that Cream of Tartar, after diſſolving a certain quantity of the reguline ſubſtance, ſeparates from it afterwards? Or is the Cream of Tartar itſelf decompoſed by too long boiling? This deſerves to be particularly inquired into, as well as the nature of the Metallic Salt, which reſults from the union of the Acid of Tartar with the Regulus of Antimony.

Cryſtal of Tartar acts alſo on ſeveral other metallic ſubſtances, and particularly on Lead; with which it forms a Salt, reſembling Tartarized Tartar in the figure of its cryſtals.

CHAP. V.

Of the PRODUCT *of* ACETOUS FERMENTATION.

PROCESS I.

Subſtances ſuſceptible of the Acetous Fermentation turned into Vinegar.

THE Wine, the Cyder, or the Malt-liquor, which you intend to convert into Vinegar, being firſt thoroughly mixed with its lees, and with the Tartar it may have depoſited,

ſited, put your liquor into a vat uſed before, either for making or for holding Vinegar. This veſſel muſt not be quite full, and the external air muſt have acceſs to the liquor contained in it. Set it where the air may have a degree of warmth anſwering nearly to the twentieth degree above 0 in Mr. de Réaumur's Thermometer. Stir the liquor from time to time. There will ariſe in it a new fermentative motion, accompanied with heat: its vinous odour will gradually change, and turn to a ſour ſmell, which will become ſtronger and ſtronger, till the fermentation be finiſhed, and ceaſe of itſelf. Then ſtop your veſſel cloſe; the liquor it contains will be found converted into Vinegar.

OBSERVATIONS.

All ſubſtances that have undergone the ſpirituous fermentation are capable of being changed into an Acid, by paſſing through this ſecond fermentation, or this ſecond ſtage of fermentation. Spirituous liquors, ſuch as Wine, Cyder, Beer, being expoſed to a hot air, grow ſour in a very ſhort time. Nay, theſe liquors, though kept with all poſſible care, in very cloſe veſſels, and in a cool place, degenerate at laſt, change their natures, and inſenſibly turn ſour. Thus the product of ſpirituous fermentation naturally and ſpontaneouſly degenerates to an Acid.

For this reaſon it is of great importance, in making Wine, or any other vinous liquor, to ſtop the fermentation entirely, if you deſire the Wine ſhould contain as much Spirit as poſſible. It is even more advantageous to check the fermentation a little before it comes to the height, than afterwards: becauſe the fermentation, though ſlackened, and in appearance totally ceaſed, ſtill continues in the veſſels; but in a manner ſo much the leſs perceptible, as it proceeds more ſlowly. Thus thoſe liquors, in which the fermentation is not quite finiſhed, but checked, continue for ſome time to gain more Spirit: whereas, on the contrary, they degenerate and gradually turn ſour, if you let the ſpirituous fermentation go on till it be entirely finiſhed.

The production of the ſecond fermentation, which we are now to conſider, is an Acid of ſo much the greater ſtrength, the ſtronger and more generous the ſpirituous liquor, in which it is excited, originally was. The ſtrength of this Acid, commonly called *Vinegar*, depends likewiſe, in a great meaſure, on the methods uſed in fermenting the vinous liquor, in order to convert it into Vinegar: for if it be fermented in broad, flat veſſels, and left to grow ſour of itſelf, the ſpirituous part will be diſſipated, and the liquor, though ſour indeed, will be vapid and effete.

The Vinegar-makers, to increaſe the ſtrength of their Vinegar, uſe certain methods of which they make a myſtery, keeping them very ſecret. However, Mr. Boerhaave gives us, from ſome Authors, the following deſcription of a proceſs for making Vinegar.

" Take two large oaken Vats or Hogſheads, and in each " of theſe place a wooden grate or hurdle, at the diſtance " of a foot from the bottom. Set the veſſel upright, and " on the grates place a moderately cloſe layer of green twigs, " or freſh cuttings of the vine. Then fill up the veſſel with " the foot-ſtalks of grapes, commonly called the *Rape*, to " within a foot of the top of the veſſel, which muſt be left " quite open.

" Having thus prepared the two veſſels, pour into them " the Wine to be converted into Vinegar, ſo as to fill one " of them quite up, and the other but half full. Leave " them thus for twenty-four hours, and then fill up the half-" filled veſſel, with liquor from that which is quite full, " and which will now in its turn be left only half-full. " Four and twenty hours afterwards repeat the ſame opera-" tion, and thus go on, keeping the veſſels alternately full " and half-full, during every twenty-four hours, till the Vi-" negar be made. On the ſecond or third day there will " ariſe, in the half-filled veſſel, a fermentative motion, ac-" companied with a ſenſible heat, which will gradually in-" creaſe from day to day. On the contrary, the fermenting " motion is almoſt imperceptible in the full veſſel; and as " the two veſſels are alternately full and half-full, the fer-" mentation is by that means, in ſome meaſure, inter-" rupted, and is only renewed every other day, in each veſ-" ſel.

" When this motion appears to be entirely ceaſed, even " in the half-filled veſſel, it is a ſign that the fermentation " is finiſhed; and therefore the vinegar is then to be put " into common caſks, cloſe ſtopped, and kept in a cool " place.

" A greater or leſs degree of warmth accelerates or checks " this, as well as the ſpirituous fermentation. In France it " is finiſhed in about fifteen days, during the ſummer; but " if the heat of the air be very great, and exceed the twenty-" fifth degree of Mr. de Réaumur's Thermometer, the half-" filled veſſel muſt be filled up every twelve hours; be-

" cauſe, if the fermentation be not ſo checked in that time, " it will become ſo violent, and the liquor will be ſo heat- " ed, that many of the ſpirituous parts, on which the " ſtrength of the Vinegar depends, will be diſſipated; ſo " that nothing will remain, after the fermentation, but a " vapid waſh, ſour indeed, but effete. The better to pre- " vent the diſſipation of the ſpirituous parts, it is a proper " and uſual precaution to cloſe the mouth of the half-filled " veſſel, in which the liquor ferments, with a cover made " alſo of oak-wood. As to the full veſſel, it is always " left open, that the air may act freely on the liquor it " contains: for it is not liable to the ſame inconveniencies, " becauſe it ferments but very ſlowly."

The vine-cuttings and grape-ſtalks, which the Vinegar-makers put into their veſſels, ſerve to increaſe the ſtrength of the liquor. Theſe matters contain a very manifeſt and perceptible Acid. They alſo ſerve as a ferment; that is, they diſpoſe the Wine to become eager more expeditiouſly, and more vigorouſly. They are the better, and the more efficacious, for having been once uſed, becauſe they are thereby thoroughly drenched with the fermented Acid: and therefore the Vinegar-makers lay them by, for preparing other Vinegar, after waſhing them nimbly in running water, in order to free them from a viſcid oily matter, which ſettles on them during the fermentation. This matter muſt by all means be removed; becauſe it is diſpoſed to grow mouldy and rot; ſo that it cannot but be prejudicial to any liquor into which you put it.

As the Acetous fermentation differs from the Spirituous in its production, ſo it doth in many circumſtances attending it. 1. Motion and agitation are not prejudicial to the Acetous fermentation, as they are to the Spirituous; on the contrary, moderate ſtirring, provided it be not continual, is of ſervice to it. 2. This fermentation is accompanied with remarkable heat; whereas, the warmth of the ſpirituous fermentation is ſcarce ſenſible. 3. I do not believe there ever was an inſtance of the vapour that riſes from a liquor in Acetous fermentation proving noxious, and producing either diſorders or ſudden death, as the vapour of fermenting Wine doth. 4. Vinegar depoſites a viſcid oily matter, as hath juſt been obſerved, very different from the Lees and Tartar of Wine. Vinegar never depoſites any Tartar; even though new Wine, that hath not yet depoſited its Tartar, ſhould be uſed in making it.

The following proceſſes will give us occaſion to treat of the nature of Vinegar, and the principles of which it conſiſts.

PROCESS II.

To concentrate Vinegar by Froſt.

EXPOSE to the air, in froſty weather, the Vinegar you deſire to concentrate. Icicles will form in it; but the whole liquor will not freeze. Take out thoſe icicles: and if you deſire a further concentration of your Vinegar by this method, the liquor which did not freeze the firſt time muſt be expoſed to a ſtronger froſt. More icicles will form therein, which muſt likewiſe be ſeparated, and kept by themſelves. The liquor which doth not freeze this ſecond time will be a very ſtrong concentrated Vinegar.

OBSERVATIONS.

LIQUORS, replete with an Acid, freeze with much more difficulty than pure water. Thus, if a very aqueous acid liquor be expoſed to froſt, ſome of the water in the liquor will preſently freeze; while the reſt, being rendered more acid by the ſeparation of the frozen phlegm, will remain fluid, and reſiſt the degree of cold which freezes water. Now Vinegar, being an acid liquor containing much water, may therefore be highly concentrated by freezing its phlegm in this manner; and the more icicles you get from it, the ſtronger and more active will the remaining Vinegar be.

Mr. Stahl was the firſt, I believe, who thus made uſe of congelation, for procuring a very ſtrong Acid of Vinegar. Mr. Geoffroy hath ſince taken the ſame method. A curious and circumſtantial account of his experiments, on this ſubject, are printed in the Memoirs of the Academy for 1739.

As it was exceſſive cold in the winter of that year, Mr. Geoffroy took the opportunity of expoſing to the froſt ſeveral Vinegars of different ſtrengths; and he determined the degree of Acidity in each, both before and after their concentration, in order to compare them, and diſcover how much ſtronger each Vinegar was rendered by the freezing of the aqueous part. To determine the ſtrength of the Vinegars, he made uſe of the method pointed out by Mr. Homberg and Mr. Stahl. This method conſiſts in combining to the exact point of ſaturation, a certain quantity of Vinegar with well-dried Salt of Tartar. The more Salt of Tartar is required, to abſorb and perfectly neutralize the Vinegar, the ſtronger it muſt be reckoned; becauſe the quantity of Alkali neceſſary to conſtitute a Neutral Salt is always proportioned to the quantity of Acid in that Salt.

One of the Vinegars employed in Mr. Geoffroy's experiments, two drams of which were entirely abſorbed by ſix grains of Salt of Tartar, having been concentrated by once freezing, and thereby reduced from eighteen quarts to ſix, he found it ſo increaſed in ſtrength, that two drams thereof required twenty-four grains of Salt of Tartar to abſorb them.

The firſt icicles that ſeparate from Vinegar, in this proceſs, are perfectly clear, and as inſipid as water. As the Vinegar becomes more concentrated, the plates of ice becoming thinner, more ſpongy, and flaky like ſnow, retain between them ſome portion of the Acid; and it is proper to begin to ſave them as ſoon as they appear to be ſenſibly acid.

Mr. Geoffroy carried the concentration of Vinegar as far as the cold of that winter in 1739 would allow him; and eight quarts of Vinegar, already concentrated by froſt in the preceding years, being reduced to two quarts and a half by the froſt of the 19th of January, the coldeſt day of that year, was found to be ſo ſtrong, that two drams thereof required forty-eight grains of Salt of Tartar to abſorb them. The icicles of this Vinegar, being thawed, retain ſo much ſtrength as to require thirteen grains of the Salt of Tartar to abſorb them.

Vinegar ſuffers no decompoſition by the congelation of its phlegm, and the conſequent concentration of its Acid. What is left ſtill contains all the principles of which Vinegar conſiſts. Its principles are only brought nearer together, and into a ſmaller compaſs: and for this reaſon it grows the thicker the more it is concentrated. When therefore you deſire to concentrate the Acid of Vinegar, and at the ſame time to purify it, that is, to free it from ſome of its oil and earth, you muſt have recourſe to diſtillation.

Wine, as well as Vinegar, may be concentrated by freezing. Mr. Stahl expoſed ſeveral ſorts of Wine to the froſt, and by that means ſeparated from them about two thirds, or three quarters, of almoſt pure phlegm. The remainders of the Wines ſo concentrated were of a ſomewhat thickiſh conſiſtence. They were very ſtrong, and kept for ſeveral years without altering, in places where the free acceſs of the air, alternately cold and hot according to the ſeaſons, would have ſoured, or ſpoiled, any other kind of Wine in the ſpace of a few weeks.

Wine thus concentrated by freezing is not thereby decompoſed, any more than Vinegar: it is only dephlegmated. By the addition of as much water as was ſeparated from it, you may reſtore it to its former condition; in which reſpect it differs greatly from the reſidue of Wine whoſe ſpirituous part, with a proportion of its phlegm, hath been drawn off by diſtillation: for though you mix that reſidue again with the principles you ſeparated from it, you can never make Wine of it again; the ſpirituous part being no longer in a capacity to combine with the other principles of the Wine, in the ſame manner as before that ſeparation. And this ſhews that heat, beſides ſeparating the moſt volatile parts, produces moreover a conſiderable change in the diſpoſition of thoſe which did not riſe in the firſt diſtillation.

Since the above experiments were made by Meſſrs. Stahl and Geoffroy, concentration by freezing is pretty frequently practiſed in laboratories; but on Vinegar only, ſeldom on Wine: becauſe, when Vinegar is thus concentrated, a much ſtronger Acid is more eaſily and more expeditiouſly obtained from it, as will be ſhewn in the following proceſs; whereas the diſtillation, as well as the quality, of Spirit of Wine is much the ſame, whether the Wine it is obtained from be concentrated or no. The reaſon of this difference is, that Spirit of Wine, being very light, riſes in diſtillation before the phlegm; whereas the Acid of Vinegar, being much more ponderous, riſes only at the ſame time with the aqueous part, or even after it.

PROCESS III.

Vinegar analyzed by Diſtillation.

INTO a glaſs or ſtone cucurbit put the Vinegar to be diſtilled; fit to it a glaſs head; place your alembic in the ſand-bath of a diſtilling furnace, and lute on a receiver. Apply a very gentle heat at firſt. A clear, limpid, light liquor will riſe, and fall in diſtinct drops, like water, from the noſe of the alembic.

Continue diſtilling this firſt liquor, till the vinegar contained in the cucurbit be diminiſhed about a fourth part. Then ſhift your receiver, and increaſe the fire a little. A clear liquor will ſtill come over, but heavier and more acid than the former. Diſtil in this manner, till you have drawn off, into your ſecond receiver, two-thirds of the liquor that was left in the cucurbit.

A thick matter will now remain at the bottom of the ſtill: put it into a retort; lute on a receiver; ſet your retort in a reverberating furnace, and diſtil with degrees of fire. There will come over a limpid liquor, very acid and ſharp, yet ponderous, and requiring a great degree of fire to raiſe it; on which account it makes the receiver very hot. It hath a ſtrong empyreumatic ſmell. When the diſtillation begins to ſlacken, increaſe your fire. There will riſe an Oil of a fetid, quick ſmell. At laſt, when nothing more will riſe with the ſtrongeſt fire, break the retort, and in it you will find a black charred matter: burn it, and from the aſhes lixiviated with water you will obtain a Fixed Alkali.

OBSERVATIONS.

None of the liquors that come over in this operation, before the laſt fetid Oil, ſeem to have any other properties than thoſe of an oily Acid; none of them is inflammable, none of them reſembles Spirit of Wine; but all of them being thrown into the fire extinguiſh it. Mr. Boerhaave however takes notice, that a Chymiſt, named Vigani, affirms the firſt portion of the liquor which riſes in the diſtillation of Vinegar to be inflammable, and no other than Spirit of Wine. Mr. Boerhaave ſuſpected that this might happen from Vigani's having diſtilled Vinegar too newly made; and found upon trial that Vinegar, being diſtilled ſoon after it was made, yielded at firſt in diſtillation a certain quantity of an Ardent Spirit; but that the ſame thing did not happen in the diſtillation of old Vinegar. And this proves that fermentation hath the ſame effect on Vinegar as on Wine; that is, that though the fermentation which produces theſe liquors ſeems to be over in a certain time, when the violent inteſtine commotion ceaſes, yet it ſtill continues in the veſſels for a conſiderable time after, though it be imperceptible. Thus, the portion of Ardent Spirit, obtained from ſome Vinegars, comes from a ſmall quantity of Wine, which ſtill remains unchanged in theſe Vinegars, not having had time enough to turn ſour. For it is certain, from the experiments of all other Chymiſts as well as Mr. Boerhaave, that Vinegar, when old enough, yields no Ardent Spirit in diſtillation.

But though old and well-made Vinegar yields no Ardent Spirit in diſtillation, we cannot thence conclude that it contains none. On the contrary, there are experiments which demonſtrate that ſome of the Ardent Spirit, which was in the Wine before it was turned into Vinegar, ſtill remains; but probably ſo combined and blended with the acid part, that it cannot be ſeparated and rendered perceptible but by peculiar proceſſes.

Mr. Geoffroy obtained an Ardent Spirit from Vinegar, by diſtilling it as ſoon as it was concentrated by freezing. "This ſpirit," ſays he *, "is the firſt liquor that riſes. At "firſt it hath only the ſame degree of inflammability as "brandy; but, when re-diſtilled in the *balneum mariæ*, it "fires gun-powder, like the beſt rectified Spirit of Wine: "with this difference, that our Spirit is impregnated with "an oil of an acrid taſte and empyreumatic ſmell, which "makes it yellow, and imparts its odour to it. This Spirit, "at leaſt that which comes over firſt, retains none of the "Acid of the Vinegar; ſeeing it neither changes the tincture "of violets, nor efferveſces with Salt of Tartar."

Mr. Geoffroy obſerves, that, if Vinegar concentrated by freezing be afterwards kept for ſeveral years, no Ardent Spirit will then be obtained from it by diſtillation. And this confirms what we ſaid of unconcentrated Vinegar, and gives reaſon to think that the Ardent Spirit obtained from Vinegar, either by diſtilling it after concentration by freezing, or by other proceſſes of which we ſhall treat in the ſequel, is foreign to the Vinegar, and is only found therein, as was ſaid above, becauſe Vinegar contains a certain quantity of Wine which hath not altered its nature. For the Spirit of Wine we obtain from Vinegar doth not hinder our obtaining from it a great deal of Acid, which being more ponderous riſes after it. Mr. Geoffroy gives the following account of the ſequel of his analyſis of Vinegar by diſtillation.

"Continuing to diſtil in a *balneum mariæ* the concen-"trated Vinegar, of which I had employed four pounds "two ounces, there was left, after the diſtillation, a reſi-

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* Memoirs of the Academy for 1729.

" duum of fourteen ounces; which could not riſe, becauſe " it was too thick. I found it covered with a ſaline cruſt, " which is the true Eſſential Salt of Vinegar, and not of " the ſame nature with Tartar: for Tartar of Wine is ſcent- " leſs; whereas the Salt of Vinegar hath a pungent ſmell, " being the Acid of Tartar ſubtilized by its union with " the Sulphureous parts. If a ſand-bath be now uſed, in- " ſtead of the *balneum mariæ*, to carry on the diſtillation " without burning the matter, part of this Salt will be re- " ſolved, and yield the laſt Acid Spirit, which is the ſtrong- " eſt that can be obtained.

" After I had, by a ſand-heat, extracted all the Acid " Spirit that the ſeveral reſiduums put together would yield, " I found at the bottom of the cucurbit a brown maſs, " of the conſiſtence of a pretty ſolid extract. Of this I " put into a retort two pounds, together with ſix pounds " of ſand well waſhed and very dry; and, applying a gra- " duated heat, I firſt obtained ſix ounces of an Acid Spirit, " that ſmelt very ſtrong of the empyreuma, and was a lit- " tle coloured with ſome portion of oil; ſeven ounces of " Spirit, having a volatile urinous ſmell, came over next: " at laſt the white vapours appeared more and more denſe. " A volatile concrete Salt adhered to the ſides of the bal- " lon, and I found four ounces of a thick fetid Oil float- " ing on the Spirit. The concrete volatile Salt, when " collected, weighed two drams. The black matter re- " maining in the bottom of the retort, being calcined and " lixiviated, yielded a fat alkaline Salt, which it is almoſt " impoſſible to dry."

I have given this account of Mr. Geoffroy's analyſis of Vinegar at length, only becauſe it differs in ſeveral reſpects from that deſcribed in the proceſs, which is Mr. Boerhaave's, as well as from thoſe delivered by ſeveral other Authors, who make no mention either of the ſaline matter, which Mr. Geoffroy found on the reſiduum of Vinegar, after its firſt diſtillation in the *balneum mariæ*, or of the volatile urinous Spirit and Salt, which he obtained from that reſiduum.

Theſe differences may ariſe either from the manner of diſtilling the Vinegar, or from Mr. Geoffroy's Vinegar having been concentrated by freezing, or rather from the quantity, and, above all, from the age of the Vinegar, examined by thoſe different Chymiſts.

The diſtillation of Vinegar ſerves not only to ſeparate its Acid from a conſiderable quantity of earth and oily parts, with which it is entangled, but alſo to dephlegmate and concentrate it. Yet Mr. Lemeri affirms, that Vinegar is not diſtilled with a view to dephlegmate it. He condemns the common method of throwing away the firſt runnings as uſeleſs phlegm, and ſaving only what comes off afterwards; having, he ſays, obſerved, that the phlegm of Vinegar cannot be abſtracted, like that of many other acid liquors, and that what comes over firſt is almoſt as ſharp as what riſes afterwards, be the fire applied at firſt ever ſo ſmall.

There is reaſon to think that Mr. Lemeri did not carefully enough examine the ſtrength of his Spirit of Vinegar, at the different ſtages of his diſtillation: for Mr. Geoffroy, in the Memoir above cited, gives an account of a diſtillation of Vinegar, the product whereof he examined with care, having for that purpoſe divided it into five different portions: and his experiments put it beyond all doubt, that the firſt portions of Spirit of Vinegar are far from being ſo acid as the laſt. This Vinegar was ſo ſtrong before diſtillation, that it required ſix grains of Salt of Tartar to abſorb two drams of it. Two drams of the firſt portion of his Spirit were abſorbed by three grains only of Salt of Tartar: the Acid of the ſecond portion took five grains to abſorb it. (Each experiment was made with two drams of Vinegar). The third portion was abſorbed by ten grains; the fourth by thirteen, and the fifth took no leſs than nineteen: which proves that Vinegar, like moſt other Acids, may be concentrated by diſtilling off the moſt aqueous part, which is lighter than the Acid.

There are therefore two ways of concentrating Vinegar, and ſeparating its moſt acid part, namely diſtillation and congelation. Theſe two methods may be ſucceſſively applied to the ſame Vinegar, and a very powerful Acid obtained by their concurrence. Mr. Geoffroy having expoſed to the froſt, on the 19th of January 1739, the laſt ruſſet-coloured liquor, drawn from the reſiduum of diſtilled Vinegar, found it ſo concentrated thereby, that it required ſixty grains of Salt of Tartar to abſorb two drams of it.

CHAP. VI.

The ACID *of* VINEGAR *combined with different* SUBSTANCES.

PROCESS I.

The Acid of Vinegar combined with alkaline Subſtances. Foliated Salt of Tartar, or Regenerated Tartar. Decompoſition of that Salt.

INTO a glaſs cucurbit put ſome very pure and well-dried Salt of Tartar; and pour on it ſome good diſtilled Vinegar, by little and little at a time. An effervеſcence will ariſe. Pour on more Vinegar, till you attain the point of ſaturation. Then fit a head to the cucurbit; ſet it in a ſand-bath; and having luted on a receiver, diſtil with a gentle heat, and very ſlowly, till nothing remain but a dry matter. On this reſiduum drop a little of the ſame Vinegar; and if any effervеſcence appears, add more Vinegar till you attain the point of ſaturation, and diſtil again as before. If you obſerve no effervеſcence, the operation was rightly performed.

OBSERVATIONS.

IT is not eaſy to hit the exact point of ſaturation in preparing this Neutral Salt; becauſe the oily parts, with which the Acid of Vinegar is loaded, hinder it from acting ſo briſkly and readily as it would do, if it were as pure as the Mineral Acids: and for this reaſon it often happens, that, when we have nearly attained the point of ſaturation, the addition of an Acid makes no ſenſible effervеſcence, though the Alkali be not yet entirely ſaturated; which deceives the operator, and makes him conclude erroneouſly that he hath attained the true point of ſaturation.

But he eaſily perceives his miſtake, when, after having ſeparated from this ſaline compound all its ſuperfluous moiſture by diſtillation, he drops freſh Vinegar upon it: for then the Salts being more concentrated, and conſequently more active, produce an effervefcence, which would not have been fenſible if this laſt portion of Acid, inſtead of coming into immediate contact with the dried Alkali, could not have mixed therewith till diffuſed through, and in a manner ſuffocated by, that phlegm from which the Acid of the Vinegar, before neutralized, was gradually ſeparated by its combining with the Alkali; that phlegm keeping in ſolution both the Neutral Salt already formed, and the Alkali not yet ſaturated. And for this reaſon it is neceſſary to try, after the firſt deſiccation of this Salt, which is called *Regenerated Tartar*, whether or no the juſt point of ſaturation hath been attained.

It may alſo happen, that, though the point of ſaturation was exactly hit at firſt, this compound Salt ſhall nevertheleſs, after deſiccation, effervefce with freſh Vinegar, and therefore not be in a perfectly neutral ſtate at that time. In this caſe the Salt muſt have been dried by too violent a fire, and partly decompounded by an exceſs of heat carrying off ſome of the Acid, which does not adhere very ſtrongly to the Alkali. This is one of the reaſons why it is neceſſary that Regenerated Tartar be deſiccated with a very gentle heat.

From what hath been ſaid, concerning the deſiccation of this Neutral Salt, it is plain, that the uſe of it is only to free the Salt from the great quantity of ſuperfluous moiſture wherein it is diſſolved: which proves that the Acid of Vinegar, like all other Acids diſſolved in much water, is ſeparated from moſt of this redundant phlegm by being combined with a Fixed Alkali. And hence we muſt conclude, that the Acid of Vinegar, contained in Regenerated Tartar deſiccated, is vaſtly ſtronger and more concentrated than it was before: and accordingly Mr. Geoffroy, having decompounded this Salt, by the means of concentrated Oil of Vitriol, obtained a Spirit of Vinegar in white vapours, which was very volatile and very ſtrong, but perhaps ſomewhat depraved with a taint of the Vitriolic Acid.

Though the Acid of Vinegar be freed, by combining with a Fixed Alkali, from a great quantity of ſuperfluous phlegm, as was ſhewn above; yet the oily parts with which it is entangled ſtill cleave to it: theſe parts are not ſeparated from it by its converſion into a Neutral Salt, but, without quitting it, combine alſo with the Fixed Alkali; and this gives Regenerated Tartar a ſaponaceous quality, and ſeveral other peculiar properties.

Regenerated Tartar, when dried, is of a brown colour. It is ſemi-volatile; melts with a very gentle heat, and then reſembles an unctuous liquor; which indicates its containing an Oil: when caſt upon live coals it flames; and, when diſtilled with a ſtrong heat, yields an actual oil; all which evidently prove the exiſtence of that Oil.

This Salt is ſoluble in Spirit of Wine; a quality which it probably owes alſo to its Oil. It requires about ſix parts of Spirit of Wine to diſſolve it; and the diſſolution ſucceeds very well in a matraſs, with the help of a gentle warmth. If the Spirit of Wine be abſtracted from this ſolution, by diſtilling with a ſmall fire, the Salt remains at the bottom of the cucurbit, in the form of a dry ſubſtance compoſed of leaves lying one upon another; which hath procured it the name of *Terra Foliata Tartari*, or *Foliated Salt of Tartar*.

It is not abſolutely neceſſary that Regenerated Tartar be diſſolved in Spirit of Wine to make the Foliated Salt: for it may be procured in this form, by only evaporating the water in which it is diſſolved. But the operation ſucceeds better with Spirit of Wine; probably becauſe the ſucceſs thereof depends on uſing an exceeding gentle warmth: now Spirit of Wine evaporates with much leſs heat than water.

Regenerated Tartar may alſo be cryſtallized. If you deſire to have it in this form, combine the Acid with the Alkali to the point of ſaturation; evaporate the liquor ſlowly to the conſiſtence of a ſyrop, and ſet it in a cool place; where it will ſhoot into cluſters of cryſtals lying one upon another like feathers.

Vinegar perfectly diſſolves abſorbent matters alſo, and particularly thoſe of the animal kingdom; ſuch as Coral, Crabs-eyes, Pearls, &c. In order to a diſſolution of ſuch matters, you muſt pulverize them, put them into a matraſs, and pour on them Spirit of Vinegar to the depth of four fingers breadth: an efferveſcence will ariſe: when that is over, ſet the mixture to digeſt two or three days in a ſand-bath; then decant the liquor, filter it, and evaporate it to dryneſs with a very gentle heat. The matter which remains is called *Salt of Coral*, *of Pearls*, *of Crabs-eyes*, *&c.* according to the ſubſtances diſſolved. If, inſtead of evaporating the liquor, a Fixed Alkali be mixed therewith, the abſorbent matter, that was diſſolved by the Acid, will precipitate in the form of a white powder, which is called the *Magiſtery of Coral*, *of Pearls*, *&c.*

PROCESS II.

The Acid of Vinegar combined with Copper. Verdegris. Cryſtals of Copper. This combination decompounded. Spirit of Verdegris.

INTO a large matraſs put Verdegris in powder. Pour on it diſtilled Vinegar to the depth of four fingers breadth. Set the matraſs in a moderate ſand-heat, and leave the whole in digeſtion, ſhaking it from time to time. The Vinegar will acquire a very deep blue-green colour. When the liquor is ſufficiently coloured, pour it off by inclination. Put ſome freſh Vinegar into the matraſs; digeſt as before; and decant the liquor again when it is ſufficiently coloured. Proceed in this manner till the Vinegar will extract no more colour. There will remain in the matraſs a conſiderable quantity of undiſſolved matter. The Vinegar thus impregnated with Verdegris is called *Tincture of Copper.*

Mix theſe ſeveral Tinctures, and evaporate them with a gentle heat to a pellicle. Then ſet the liquor in a cool place: in the ſpace of a few days a great many cryſtals of a moſt beautiful green colour will ſhoot therein, and ſtick to the ſides of the veſſel. Pour off the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Continue theſe evaporations and cryſtallizations, till no more cryſtals will ſhoot in the liquor. Theſe are called *Cryſtals of Copper*, and are uſed in painting. To this combination of the Acid of Vinegar with Copper the painters and dealers have given the title of *Diſtilled Verdigris.*

OBSERVATIONS.

VERDEGRIS is prepared at Montpelier. To make it they take very clean plates of Copper, which they lay, one over another, with huſks of grapes between, and after a certain time take them out. Their ſurfaces are then covered all over with a very beautiful green cruſt, which is *Verdegris.* This Verdegris is nothing but Copper corroded by the Acid of Tartar, analagous to the Acid of Vinegar, which abounds in the Wines of Languedoc, and eſpecially in the rape, huſks, and ſtones of grapes that have a very auſtere taſte. Verdegris is a ſort of ruſt of Copper; or Copper corroded and opened by the Acid of Wine, but not yet converted intirely into a Neutral Salt: for it is not ſoluble in water, nor does it cryſtallize. This ariſes from its not being united with a ſufficient quantity of Acid. The deſign of the operation here deſcribed is to furniſh the Verdegris with the quantity of Acid requiſite to make it a true Metallic Salt: for which purpoſe diſtilled Vinegar is very fit.

Cryſtals of Copper may be obtained, without employing Verdegris, by making uſe of Copper itſelf diſſolved by the Acid of Vinegar, according to the method practiſed with reſpect to Lead, as ſhall be ſhewn hereafter. But Verdegris is generally uſed, becauſe it diſſolves ſooneſt; it being a Copper already half-diſſolved by an Acid correſpondent to that of Vinegar.

Cryſtals of Copper are decompounded by the action of fire alone, without any additament; becauſe the Acid of Vinegar adheres but looſely to Copper. In order to decompound this Salt and extract its Acid, it muſt be put into a retort, and diſtilled in a reverbatory furnace with degrees of fire. An inſipid phlegm riſes firſt, which is the water retained by the Salt in cryſtallizing. This phlegm is ſucceeded by an acid liquor, which riſes in the form of white vapours that fill the receiver. Towards the end of the diſtillation the fire muſt be violently urged, in order to raiſe the ſtrongeſt and moſt fixed Acid. At laſt there remains in the retort a black matter, which is nothing but Copper, that may be reduced by melting it in a crucible with one part of Salt-petre and two parts of Tartar. A ſimilar Acid, but more oily, and in a much ſmaller quantity, may be obtained from Verdegris by diſtillation.

The Acid, which in this diſtillation comes over after the firſt phlegm, is an exceeding ſtrong and concentrated Vinegar. It is known by the title of *Spirit of Verdegris*. Zwelfer, and after him M. le Fevre in his Chymiſtry, beſtows extraordinary praiſes on this Spirit; pretending that it will produce the Salt of Coral, and others of the ſame kind, without loſing any of its virtue, or ceaſing to be acid; ſo as to remain ſtill capable of performing other operations of the ſame nature. But Mr. Boerhaave and Mr. Lemeri poſitively deny the fact; and with good reaſon, having formed their judgments on their own experiments.

Yet I can hardly think both Zwelfer and le Fevre would have affirmed a thing of this nature, in ſuch a poſitive and confident manner, if they had been convinced in their minds that it was falſe. We muſt ſuppoſe that thoſe Chymiſts examined the matter with too little attention, and were miſled by ſome fallacious appearance. Probably they may have compared this concentrated Vinegar with common diſtilled Vinegar; they may have put to their Coral an equal doſe thereof; and, after ſaturation, they may have diſtilled off the ſuperfluous liquor, which may have effervefced with freſh Coral and diſſolved it. Surpriſed at this effect, they may have imagined that their Acid had loſt none of its ſtrength, and that it had the virtue of converting into Salt any quantity of Coral, or ſuch other matters, without any prejudice to its Acidity. A raſh concluſion: which certainly they never would have made, if they had carried the experiment far enough; if they had diſſolved a third or a fourth quantity of Coral in their Vinegar: for they would have been thereby convinced that the Spirit of Verdegris, like all other acid Spirits, depoſites and leaves its Acid in abſorbent matters; and that if the liquor, which they drew off by diſtillation from their firſt Salt of Coral, was ſtill acid, and capable of diſſolving freſh Coral, nothing could be inferred from thence but that Spirit of Verdegris is an exceedingly concentrated Vinegar, which, in the ſame quantity of liquor, contains much more Acid than the ſtrongeſt diſtilled Vinegar prepared in the common way; that therefore a much ſmaller doſe thereof is required to convert a given quantity of Coral into Salt; and that the liquor, which they diſtilled from their firſt Salt, ſtill retained ſome of its virtue, only becauſe it was replete with much more Acid than could be neutralized by the Coral. But a love of the marvellous ſo prepoſſeſſes the mind of man, that it often hinders him from perceiving the moſt obvious facts. This is the fault of all the ancient Chymiſts in general: and I believe the only reaſon why we find their books ſtuffed with ſo many unſucceeding experiments was, that their heated imaginations frequently repreſented things to them otherwiſe than they really were.

PROCESS III.

The Acid of Vinegar combined with Lead. Ceruſe. Salt or Sugar of Lead. This combination decompounded.

INTO the glaſs head of a cucurbit, put thin plates of Lead, and ſecure them ſo that they may not fall out when the head is put upon the cucurbit. Fit on this head to a wide-mouthed cucurbit containing ſome Vinegar. Set it in a ſand-bath; lute on a receiver, and diſtil with a gentle heat for ten or twelve hours. Then take off the head: in it you will find the leaden plates covered, and, in a manner, cruſted over with a white matter. This being bruſhed off with a hare's foot is what we call *Ceruſe*. The leaden plates thus cleanſed may be employed again for the ſame purpoſe, till they be wholly converted into Ceruſe by repeated diſtillations. During the operation there will come over into the receiver a liquor ſomewhat turbid and whitiſh. This is a diſtilled Vinegar in which ſome Lead is diſſolved.

Reduce a quantity of Ceruſe into powder; put it into a matraſs; pour on it twelve or fifteen times as much diſtilled Vinegar; ſet the matraſs in a ſand-bath; leave the matter in digeſtion for a day, ſhaking it from time to time: then decant your liquor, and keep it apart. Pour freſh Vinegar on what is left in the matraſs, and digeſt as before. Proceed thus till you have diſſolved one half, or two thirds, of the Ceruſe.

Evaporate to a pellicle the liquors you poured off from the Ceruſe, and ſet them in a cool place. Greyiſh cryſtals will ſhoot therein. Decant the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Proceed thus evaporating and cryſtallizing, as long as any cryſtals will ſhoot. Diſſolve your cryſtals in diſtilled Vinegar, and evaporate the ſolution, which will then ſhoot into whiter and purer cryſtals. This is the *Salt* or *Sugar of Lead*.

OBSERVATIONS.

LEAD is eaſily diſſolved by the Acid of Vinegar. If it be barely expoſed to the vapour of that Acid, its ſurface is corroded, and converted into a kind of calx or white ruſt, much uſed in painting, and known by the name of *Ceruſe* or *White Lead*. But this preparation of Lead is not combined with a ſufficient quantity of Acid to convert it into a Salt: is is no more than lead divided and opened by the Acid of Vinegar; a matter which is to Lead what Verdegris is to Copper. And therefore if you deſire to combine Ceruſe with the quantity of Acid neceſſary to convert it into a true Neutral Salt, you muſt treat it in the ſame manner as we did Verdegris, in order to procure Cryſtals of Copper; that is, you muſt diſſolve it in diſtilled Vinegar, as the proceſs directs.

The Salt of Lead is not very white when it firſt ſhoots; and for this reaſon it is diſſolved again in diſtilled Vinegar, and cryſtallized a ſecond time. If ſalt of Lead be repeatedly diſſolved in diſtilled Vinegar, and the liquor evaporated, it will grow thick; but cannot be deſiccated without great difficulty. If the ſame operation be oftener repeated, this quality will be thereby more and more increaſed; till at laſt it will remain on the fire like an Oil, or melted Wax: it coagulates as it cools, and then looks, at firſt ſight, like a metallic maſs, ſomewhat reſembling Silver. This matter runs with a very gentle heat, almoſt as eaſily as wax.

The Salt of Lead hath a ſaccharine taſte, which hath procured it the name alſo of Sugar of Lead. For this reaſon when Wine begins to turn ſour, the ready way to cure it of that diſagreeable taſte is, to ſubſtitute a ſweet one which is not diſagreeable to the taſte, by mixing therewith Ceruſe, Litharge, or ſome ſuch preparation of Lead: for the Acid of the Wine diſſolves the Lead, and therewith forms a Sugar of Lead, which remains mixed with the Wine, and hath a taſte which, joined with that of the Wine, is not unpleaſant. But, as Lead is one of the moſt dangerous poiſons we know, this method ought never to be practiſed; and whoever employs ſuch a pernicious drug deſerves to be moſt ſeverely puniſhed. Yet ſomething very like this happens every day, and muſt needs have very bad conſequences; while there is nobody to blame, and thoſe to whom the thing may prove fatal can have no miſtruſt of it.

All the retailers of Wine have a cuſtom of filling their bottles on a counter covered with Lead, having a hole in the middle, into which a leaden pipe is ſoldered. The Wine which they ſpill on the counter, in filling the bottles, runs through this pipe into a leaden veſſel below. In that it uſually ſtands the whole day, or perhaps ſeveral days; after which it is taken out of the leaden veſſel, and mixed with other Wine, or put into the bottle of ſome petty cuſtomer. But, alas for the man to whoſe lot ſuch Wine falls! He muſt feel the moſt fatal effects from it; and the danger to which he is expoſed is ſo much the greater, the longer the Wine hath ſtood in the leaden veſſel, and thereby acquired more of a noxious quality. We daily ſee cruel diſtempers among the common people, occaſioned by ſuch cauſes, which are not ſufficiently attended to.

Wine that is not kept in cloſe veſſels is apt to turn ſour very ſoon, eſpecially in the ſummer; and the retailers of Wine have obſerved that their drippings, thus collected in veſſels of Lead, are not liable to this inconvenience. This is what hath eſtabliſhed among them the practice I am ſpeaking againſt. As they ſee only the good effects thereof, of, and know nothing of its ill conſequences, we cannot be angry with them. It is natural to think, that, as Lead hath the property of keeping Wine cool, it may by that means prevent its growing ſour for ſome time; and perſons who are not verſed in Chymiſtry can hardly ſuſpect that Wine is preſerved from being pricked, only by being converted into a kind of poiſon. Yet this is the very caſe: for Lead doth not hinder the Wine from growing ſour; but, uniting with its Acid, as ſoon as it appears, and forming therewith a Sugar of Lead, changes the taſte thereof as hath been ſaid, and hinders the Acid from affecting the palate.

Hence it appears how much it were to be wiſhed that the uſe of thoſe counters covered with Lead were aboliſhed entirely. I am informed, by a Chymiſt zealous for the public good *, that he repreſented this matter to the Magiſtrates ſeveral years ago. It is not to be doubted, that, when the dealers in Wine know the ill conſequences attending this practice, they will with pleaſure ſacrifice the ſmall benefit they receive from it to the public ſafety.

It is eaſy to prove whether or no a ſuſpected Wine contains Lead. You need only pour into it a little Oil of Tartar *per deliquium;* or, if you have not that at hand, a lye of the aſhes of green wood. If there be any Lead diſſolved in it, the liquor will immediately grow turbid, and the Lead will precipitate in the form of a white powder; becauſe the Sugar of Lead it contains, being a Neutral Salt, whoſe baſis is a metal, is decompounded by the Fixed Alkali, which ſeparates that metal from the Acid. Lead thus ſeparated from the Acid of Vinegar by an Alkali is called *Magiſtery of Lead.*

Ceruſe, or White Lead, is alſo a very dangerous poiſon. It is a pigment very much uſed, being the only White that can be applied with Oil. This White is the moſt common, or, perhaps, the only cauſe of thoſe dreadful colics with which painters, and all that work in colours, are frequently afflicted. This induced me to examine all the ſubſtances capable of affording a White, in order to find one, if poſſible, which might be ſubſtituted for White Lead: but, after a vaſt number of experiments, I had the mortification to be convinced, that all Whites, even the brighteſt and moſt beautiful, which are not metallic, produce nothing, when ground with Oil, but greys, or dirty yellows. There is ſtill ſomething to be hoped for in Whites obtainable from certain metallic ſubſtances: but, as every one of thoſe matters may be ſuſpected of ſome noxious quality, long experience alone will remove our juſt apprehenſions of danger from every thing afforded by ſuch ſubſtances.

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* Mr. Rouelle, whom I have had occaſion to mention ſeveral times in this work with the honour which he deſerves, and with whom I went through a courſe of Chymiſtry, when I was a Student in Medicine. It muſt be obſerved, to the praiſe of this ingenious Artiſt, that he is the firſt Frenchman that ever gave Courſes of Chymiſtry. In theſe he explains the operations according to the true and ſound Theory of the Science, drawn from the writings of Becher, Stahl, Junckər, Boyle, Boerhaave, Hoffman, and many other excellent Chymiſts, whom it would be tedious to mention here, as well as from the Memoirs of the moſt celebrated Academies, particularly thoſe of the Academy of Sciences at Paris.

To return to the Salt of Lead: it may be decompounded by diſtillation without addittament. In order to perform this, you muſt put the Salt of Lead into a glaſs or ſtone retort, leaving a full third thereof empty, and diſtil in a reverberating furnace with degrees of fire. A ſpirit riſes, which fills the receiver with clouds. When nothing more will come over with a fire that makes the retort red-hot, let the veſſels cool, and then unlute them. You will find in the receiver, an auſtere liquor, which is inflammable, or, at leaſt, an inflammable Spirit may be obtained from it, if about one half thereof be drawn off by diſtillation in a glaſs alembic. The retort in which the Salt of Lead was decompounded contains at the end of the operation, a blackiſh matter: this is Lead, which will reſume its metallic form on being melted in a crucible; becauſe the Acid by which it was diſſolved, and from which it hath been ſeparated, being of a very oily nature, hath left in it a ſufficient quantity of phlogiſton.

What is moſt remarkable in this decompoſition of Salt of Lead is the inflammable Spirit which it yields, though the Vinegar which entered into the compoſition of the Salt ſeemed to contain none at all.

CHAP.

CHAP. VII.

Of the PUTRID FERMENTATION *of* VEGETABLE SUBSTANCES.

PROCESS I.

The Putrefaction of Vegetables.

FILL a hogſhead with green plants, and tread them down a little; or, if the vegetables be dry and hard ſubſtances, divide them into minute parts, and ſteep them a little in water to moiſten them: then leave them, or the green plants, in the veſſel, uncovered and expoſed to the open air. By degrees a heat will ariſe in the center of the veſſel, which will continue increaſing daily, at laſt grow very ſtrong, and be communicated to the whole maſs. As long as the heat is moderate, the plants will retain their natural ſmell and taſte. As the heat increaſes, both theſe will gradually alter, and at laſt become very diſagreeable, much like thoſe of putrid animal ſubſtances. The plants will then be tender as if they had been boiled; or even be reduced to a kind of pap, more or leſs liquid according to the quantity of moiſture they contained before.

OBSERVATIONS.

ALMOST all vegetable matters are ſuſceptible of putrefaction; but ſome of them rot ſooner, and others more ſlowly. As putrefaction is only a ſpecies of fermentation, the effect whereof is to change entirely the ſtate of the Acid, by combining it with a portion of the earth and Oil of the mixt, which are ſo attenuated that from this union there reſults a new ſaline ſubſtance in which no Acid is diſcernible; which on the contrary hath the properties of an Alkali, but rendered Volatile; it is plain, that, the nearer the Acid of a plant ſet to putrefy is to this ſtate, the ſooner will the putrefaction of that plant be completed. Accordingly all plants that contain a Volatile Alkali ready formed, or from which it can be obtained by diſtillation, are the moſt diſpoſed to putrefaction.

Thoſe plants, in which the Acid is very manifeſt and ſenſible, are leſs apt to putrefy; becauſe all their Acid muſt undergo the change above ſpecified. But vegetable matters, whoſe Acid is entangled and clogged by ſeveral of their other principles, muſt be ſtill longer elaborated, before they can be reduced to the condition into which complete putrefaction brings all vegetables. The earthy and oily parts, in which the Acids of theſe ſubſtances are ſheathed, muſt be attenuated and divided by a previous fermentation, which, from thoſe parts ſubtilized and united with the Acid, forms an Ardent Spirit, wherein the Acid is more perceptible than in the almoſt inſipid, or ſaccharine juices, out of which it is produced. The Acid contained in the Ardent Spirit muſt be ſtill further diſengaged, before it can enter into the combination of a Volatile Alkali: conſequently the Ardent Spirit muſt undergo a ſort of decompoſition; its Acid muſt be rendered more ſenſible, and be brought to the ſame condition as the Acid of plants in which it manifeſts all its properties.

Hence it appears, that the ſpirituous and acetous fermentations are only preparatives, which nature makes uſe of, for bringing certain vegetable matters to putrefaction. Theſe fermentations therefore muſt be conſidered as advances towards that putrefaction, in which they terminate, or rather as the firſt ſtages of putrefaction itſelf. This is the opinion of Mr. Stahl, who hath treated this ſubject with great ſagacity, and thrown much light upon it.

Mr. Boerhaave is not altogether of the ſame mind. He conſiders putrefaction as ſomething foreign to fermentation; as an operation independent of it, and very different from it. He gives the title of fermentation to that inteſtine and ſpontaneous motion only which produces an Ardent Spirit, and changes it into an Acid. He founds his opinion on this, that the circumſtances attending putrefaction are different from thoſe which accompany ſpirituous and acetous fermentation; that the product of putrefaction is very different from the products of theſe fermentations; and laſtly, that all vegetable and animal ſubſtances are ſuſceptible of putrefaction, whereas only ſome kinds of them are capable of fermentation properly ſo called.

Mr. Boerhaave is ſo far right, that we ought not to confound together operations which differ in ſeveral reſpects, and reſult in different productions; but Mr. Stahl's opinion muſt nevertheleſs be looked on as highly probable, or rather abſolutely true. For it doth not neceſſarily follow, from the difference between the circumſtances and productions of fermentative motions, that the operations have no relation to, or connection with, each other. They may nevertheleſs be conſidered as different ſteps of one and the ſame operation: and if all vegetable and animal matters are not ſuſceptible of the three degrees of fermentation, we can only infer from thence that there are mixts, in which the whole work of fermentation is yet to do; and that there are others whoſe principles are ſo diſpoſed that they are in the ſame condition as if they had already undergone the firſt, or even the ſecond, degree of fermentation; and conſequently ſuch mixts are ſuſceptible only of the ſecond, or perhaps of the third, degree of fermentation.

Mr. Stahl therefore ſays very judiciouſly, that, far from denying putrefaction to be a fermentation, we ought on the contrary to conſider all fermentation as no other than putrefaction. Matters ſuſceptible of the ſpirituous and acetous fermentation do but paſs through theſe previous alterations in their way to complete putrefaction. On this principle, Wine and Vinegar are only liquors that had begun to putrefy, but were ſtopt at the firſt or ſecond ſtage of their putrefaction. This is ſo true, that, if a fermenting liquor be left to itſelf in the open air, and in a due degree of heat, it will proceed directly, without any ſtop, to perfect putrefaction.

The acetous fermentation is attended with more heat than the ſpirituous, and the putrid with ſtill more than the acetous. The heat of putrefying plants is ſometimes ſo conſiderable, that, when they are not too moiſt, and are ſtacked up in great heaps, they take fire and burn violently. Of this there are frequent inſtances in hay-ricks.

PROCESS II.

Putrefied Vegetable Subſtances analyzed.

PUT the putrefied plants you mean to analyze into a glaſs cucurbit, and ſet it in a ſand-bath. Fit to it a head; lute on a receiver; diſtil with a gentle fire, and a limpid fetid liquor will come over. Continue the diſtillation till the matter contained in the retort be almoſt dry.

Then unlute your veſſels, and keep the liquor you find in the receiver by itſelf. Put the matter remaining in the cucurbit into a retort, and diſtil with a graduated heat. There will riſe white vapours; a pretty conſiderable quantity of liquor

quor nearly like that of the former diſtillation; a Volatile Salt in a concrete form; and a black oil, which towards the end will be very thick. In the retort there will remain a black charred matter, which being burnt in the open air will fall into aſhes, from which no Fixed Alkali can be extracted.

By means of a funnel ſeparate your oil from the aqueous liquor. Diſtil this liquor with a gentle heat. You will by this means obtain a Volatile Salt like that of animals; of which you may alſo get ſome, by the ſame means, from the liquor which came over in the firſt diſtillation.

OBSERVATIONS.

This analyſis ſhews the changes which putrefaction produces in vegetable matters. Scarce any of their principles are now to be diſcerned. They now yield no aromatic liquor; no Eſſential Oil; no Acid; and conſequently no Eſſential Salt, Ardent Spirit, or Fixed Alkali: in a word, whatever their natures were before putrefaction, they are all alike when they have once undergone this fermentative motion in its full extent. Nothing can then be obtained from them but Phlegm, a Volatile Alkali, a fetid Oil, and an inſipid Earth.

Almoſt all theſe changes are owing to the tranſmutation of the Acid, which is depraved by putrefaction, and combined with a portion of the Oil and ſubtilized Earth of the mixt; ſo that the reſult of their union is a Volatile Alkali. Now, as the Fixed Alkali, found in the aſhes of unputrefied plants, is only the moſt fixed part of their earth and of their Acid, cloſely united together by the igneous motion, it is not ſurpriſing that, when all the Acid, with a part of the earth, is ſubtilized and volatilized by putrefaction, no Fixed Alkali can be found in the aſhes of putrefied Vegetables. The alteration which the Acid ſuffers by the putrefactive motion is, in my opinion, the greateſt it can undergo, without being entirely deſtroyed and decompoſed, ſo as to be no longer a Salt.

We have ſeen it, in the Mineral kingdom, in its greateſt purity and ſtrength. Its combination with Oil, and the other alterations its undergoes, in the Vegetable kingdom, have ſhewn it weakened and diſguiſed. The changes it ſuffers by the ſpirituous and acetous fermentation, have exhibited it in other forms. And laſtly, putrefaction disfigures it completely, and, in ſome ſort, changes its very nature, ſo that it cannot be diſtinguiſhed. In the animal kingdom we find it nearly in the ſame condition: for though the Vegetable ſubſtances, on which animals feed, do not undergo direct putrefaction, in its full extent, before they are converted into animal juices, yet they ſuffer moſt of the alterations produced by putrefaction; ſo that when they have acquired the qualities neceſſary to their becoming an actual nutritious animal juice, they are within one ſtep of complete putrefaction. For this reaſon all animal ſubſtances are very apt to putrefy, and are unſuſceptible of the firſt degrees of fermentation. But this diſcuſſion belongs to the animal kingdom, of which we are now going to treat in the third part of theſe Elements; the theory of putrefaction ſerving to introduce it, and naturally leading us to it.

PART III.

OF OPERATIONS ON ANIMAL SUBSTANCES.

CHAP. I.

Of MILK.

PROCESS I.

Milk ſeparated into Butter, Curd, and Whey: inſtanced in Cow's Milk.

PUT new Cow's milk into a flat earthen pan, and ſet it in a temperate heat. In ten or twelve hours time there will gather on its ſurface a thick matter, of a ſomewhat yellowiſh white: this is called *Cream*. Gently ſkim off this Cream with a ſpoon, letting the milk you take up with it run off. Put all this Cream into another veſſel, and keep it. The milk thus ſkimmed will not be quite ſo thick as before; nor will it be of ſuch a dead white, but have a little blueiſh caſt. If all the Cream be not ſeparated from it, more will gather on its ſurface after ſome time, which muſt be taken off as the former. In two or three days the ſkimmed milk will coagulate into a ſoft maſs called *Curd*, and then it taſtes and ſmells ſour.

Cut this Curd acroſs in ſeveral places. It will immediately diſcharge a large quantity of *Serum*. Put the whole into a clean linen cloth; hang it up, and underneath it ſet a veſſel to receive the Serum as it drops. When the aqueous part hath done dripping, there will remain in the filter a white ſubſtance ſomewhat harder than the curdled milk. This ſubſtance is called *Cheeſe*, and the *Serum* ſeparated from it is known by the name of *Whey*.

OBSERVATIONS.

THE milk of animals, that feed only on vegetables, is of all animal matters the leaſt removed from the vegetable nature. The truth of this will be demonſtrated by the experiments we ſhall produce by and by, for the further analyſis of milk. For this reaſon we judged, with Mr. Boerhaave, that it was proper to begin the analyſis of animals by examining this liquor.

Moſt Chymiſts juſtly conſider Milk as of the ſame nature with Chyle. Indeed there is great reaſon to think, that, except ſome ſmall differences to be afterwards taken notice of, theſe two matters are nearly the ſame. They are both of a dead white colour, like that of an emulſion; which proves that, like emulſions, they conſiſt of an oily matter divided, diffuſed, and ſuſpended, but not perfectly diſſolved, in an aqueous liquor.

It is not ſurpriſing that theſe liquors ſhould reſemble emulſions; for they are produced in the ſame manner, and may very juſtly be called *Animal Emulſions*. For how are vegetable ſubſtances converted into Chyle and Milk in an animal body? They are bruiſed, divided, and triturated by maſtication and digeſtion, as perfectly, at leaſt, as the matters pounded in a mortar to make an emulſion; and muſt thereby undergo the ſame changes as thoſe matters; that is, their oily parts, being attenuated by thoſe motions, muſt be mixed with and lodged between the aqueous parts, but not diſſolved therein; becauſe they do not, in the bodies of animals, meet with ſaline matters, ſufficiently diſentangled and active, to unite intimately with them, and by that means render them ſoluble in water.

Nevertheleſs Chyle and Milk, though produced in the ſame manner as emulſions, and very much reſembling them, differ greatly from them in ſome reſpects; owing chiefly to the time they remain in the bodies of animals, their being heated while there, the elaborations they undergo therein, and the animal juices commixed with them.

New Milk hath a mild agreeable taſte, without any ſaline pungency; nor hath any Chymical trial diſcovered in it either an Acid or an Alkali. Yet it is certain that the juices of plants, out of which milk is formed, contain many ſaline matters, and eſpecially Acids: accordingly Milk alſo contains the ſame; but the Acids are ſo ſheathed and combined, that they are not perceptible. The caſe is the ſame with all the other liquors intended to conſtitute part of an animal body: there is no perceptible Acid in any of them.

Hence it may be inferred that one of the principal changes which vegetables undergo, in order to their being converted into an animal ſubſtance, conſiſts in this, that their Acids are combined, entangled, and ſheathed in ſuch a manner that they become imperceptible, and exert none of their properties.

Milk left to itſelf, without the help of diſtillation, or any additament whatever, undergoes a ſort of decompoſition. It runs into a kind of ſpontaneous analyſis; which doth not indeed reduce it to its firſt principles, yet ſeparates it into three diſtinct ſubſtances, as the proceſs ſhews; namely, into Cream, or the buttery fat part, into Curd or Cheeſe, and into Serum or Whey: which ſhews that thoſe three ſubſtances of which Milk conſiſts, are only mixed and blended together, but not intimately united.

The firſt parts, being the lighteſt, riſe gradually to the ſurface of the liquor as they ſeparate from the reſt: and this forms the Cream.

Cream, as ſkimmed from the ſurface of Milk, is not however the pure buttery or fat part; it is ſtill mixed with many particles of Cheeſe and Whey, which muſt be ſeparated in order to reduce it into Butter. The moſt ſimple, and at the ſame time the beſt method of effecting this, is daily practiſed by the country people. It conſiſts in beating or churning the Cream, in a veſſel contrived for that purpoſe, with the flat ſide of a circular piece of wood, in the center of which a ſtaff is fixed. One would think that the motion, impreſſed on the Cream by this inſtrument, ſhould rather ſerve to blend more intimately the particles of Butter, Cheeſe, and Whey, of which it conſiſts, than to ſeparate them from each other; as this motion ſeems perfectly adapted to divide and attenuate thoſe particles. But, if we conſider what paſſes on this occaſion, we ſhall ſoon perceive that the motion by which Butter is churned is nothing like triture: for churning is no other, properly ſpeaking, than a continually repeated compreſſion, the effect whereof is to ſqueeze out from amongſt the buttery particles thoſe of Cheeſe and Whey mixed therewith; by which means the particles of Butter are brought into contact with each other, unite, and adhere together.

Milk, whether ſkimmed or no, grows ſour of itſelf, and curdles in a few days. When it is newly curdled, the Cheeſe and Whey ſeem to be united, and to make but one maſs:

but theſe two matters ſeparate ſpontaneouſly from each other, with the greateſt eaſe, and in a very ſhort time.

The acidity, which Milk naturally contracts in the ſpace of a few days, muſt be conſidered as the effect of a fermenting motion, which diſcovers in that liquor an Acid that was not perceptible before. This, properly ſpeaking, is an acetous fermentation, which Milk paſſes through in its way to putrefaction; and it ſoon follows, eſpecially if the Milk be expoſed to a hot air.

If, inſtead of leaving Milk to grow ſour and curdle of itſelf, an Acid be mixed therewith, while it is yet ſweet and newly milked, it immediately coagulates; which gives reaſon to think, that its curdling naturally is the effect of the Acid, which diſcovers itſelf therein as it grows ſtale.

The coagulation of Milk may alſo be conſiderably accelerated, by ſetting it in a ſand-bath gently heated; or by mixing therewith a little of what, in the language of the Dairy, is called *Runnet;* which is nothing but ſome curdled and half-digeſted Milk taken from the ſtomach of a Calf: or both theſe methods may be employed at once, which will produce the effect ſtill more expeditiouſly.

It is not difficult to find out the cauſe of theſe effects. The Runnet, which is Milk already curdled and grown ſour, is an actual ferment to ſweet Milk, diſpoſing it to turn ſour, much more readily: for though Milk, when thus haſtily curdled by the Runnet, hath not a manifeſtly acid taſte, yet it is certain that this Acid begins to exert itſelf. The proof thereof is, that, being expoſed to the ſame degree of heat with Milk equally new, that is not mixed with this ferment, it turns ſour much ſooner. As to the effect of heat in coagulating Milk, there is nothing extraordinary in it: we know how much it promotes and accelerates all fermentative motion. The whole of this perfectly agrees with what we ſaid before concerning fermentation.

Fixed Alkalis alſo coagulate Milk; but at the ſame time they ſeparate the Whey from the Cheeſe, which floats on the liquor in clots. They give the Milk a ruſſet-colour inclining to red; which may ariſe from their attacking the fat part.

The ſeparation of Milk into Butter, Cheeſe, and Whey, is a kind of imperfect analyſis thereof, or rather the beginning of one. In order to render it complete, we muſt examine each of theſe ſubſtances ſeparately, and find the principles of which they conſiſt. This we ſhall endeavour to do in the following proceſs.

PROCESS II.

Butter analyzed by Diſtillation.

INTO a glaſs retort put the quantity of freſh Butter you intend to diſtil. Set the retort in a reverberatory; apply a receiver, and let your fire be very gentle at firſt. The Butter will melt, and there will come over ſome drops of clear water, which will have the peculiar ſmell of freſh Butter, and ſhew ſome tokens of Acidity. If the fire be increaſed a little, the Butter will ſeem to boil: a froth will gather on its ſurface, and the phlegm, ſtill continuing to run, will gradually come to ſmell juſt like Butter clarefied in order to be preſerved. Its Acidity will be ſtronger and more manifeſt than that of the firſt drops that came over.

Soon after this, by increaſing the fire a little more, there will riſe an Oil, having nearly the ſame degree of fluidity as fat Oils; but it will grow thicker as the diſtillation advances, and at laſt will fix in the receiver when it cools. It will be accompanied with ſome drops of liquor, the Acidity whereof will always increaſe, while its quantity decreaſes, as the diſtillation advances.

While this thick Oil is diſtilling, the Butter contained in the retort, which at firſt ſeemed to boil, will be calm and ſmooth, without the leaſt appearance of ebullition; though the heat be then much greater than when it boiled. Continue the diſtillation, conſtantly increaſing the fire by degrees as you find it neceſſary for the elevation of the thick Oil. This Oil, or rather this kind of Butter, will be at laſt of a ruſſet-colour. There will riſe along with it ſome white vapours exceeding ſharp and pungent.

When you obſerve that nothing more comes over, though the retort be quite red-hot, let the veſſels cool, and unlute them. You will find in the receiver an aqueous acid liquor, a fluid Oil, and a kind of fixed brown Butter. Break the retort, and you will find therein a charred matter; the ſurface of which, where it touched the glaſs, will be of a ſhining black, and have a fine poliſh.

OBSERVATIONS.

THE analyſis of Butter proves that this ſubſtance, which is an oily matter in a concrete form, owes its conſiſtence to the Acid only, with which the oily part is combined: that is, it follows the general rule frequently mentioned above in treating of other oily compounds; the conſiſtence whereof we ſhewed to be ſo much the firmer, the more Acid they contain. The firſt portions of Oil that come over in the diſtillation of Butter are fluid, becauſe a pretty conſiderable quantity of Acid roſe before them, which being mixed with the phlegm gives it the Acidity we took notice of.

This Oil, being freed from its Acid, and by that means rendered fluid, riſes firſt; becauſe it is by the ſame means rendered lighter. The kind of Butter that comes over afterwards, though it be fixed, is nevertheleſs far from having the ſame conſiſtence as it had before diſtillation; becauſe it loſes much of its Acid in the operation. This Acid is what riſes in the form of white vapours. Theſe vapours are, at leaſt, as pungent and irritating as the Sulphureous Acid or Volatile Alkalis: but their ſmell is different: it hath a reſemblance, or rather is the ſame, with that which riſes from Butter, when it is burnt and browned in an open veſſel. But, when concentrated and collected in cloſe veſſels, as in the diſtillation of Butter, they are vaſtly ſtronger: they irritate the throat ſo as to inflame it; they are exceeding ſharp and pungent to the ſmell, and are ſo hurtful to the eyes that they quickly inflame them, as in an ophthalmy, and make them ſhed abundance of tears. The great volatility of this Acid is entirely owing to a portion of the phlogiſton of the Butter with which it is ſtill combined.

It may be aſked why Butter, or the oily part of Milk which hath the conſiſtence of a fixed Oil, is more replete with an Acid than the Oils of the vegetables whereof the Milk was formed; as theſe Oils are almoſt all fluid, which indicates their containing leſs Acid before than after they were digeſted in the body of an animal. This muſt appear the more extraordinary, becauſe the Acid contained in the liquors of animals is ſheathed and imperceptible, and conſequently incapable of combining with the Oils of vegetables ſo as to give them this conſiſtence.

I think it will be eaſy to give a ſatisfactory anſwer to this queſtion, if it be conſidered, that the Oils, which exiſt in the vegetable juices whereof the Milk is formed, are far from being combined with the whole Acid of thoſe vegetables; becauſe there is hardly a plant that doth not yield a great deal of Acid, even without the help of fire. Now, there is reaſon to think, that one of the principal effects of digeſtion is, to combine and unite this Acid, with the oily parts of vegetables, more intimately than it was before.

The further we advance in the analyſis of animals, the more we ſhall be convinced, that, in the different elaborations, which vegetable ſubſtances undergo in order to their being changed into the nutritious juices of animals, nature employs all her powers to expel, deſtroy, or at leaſt, weaken and blunt the Acids, ſo as to render them abſolutely imperceptible. One of the beſt means by which ſhe can effect this, is the combining and uniting them intimately with the oily parts: and this operation ſhe probably begins in digeſtion. She gets rid of moſt part of the Acids contained in the aliments, by thus uniting them with the Oils contained in thoſe aliments. Hence ariſes the conſiſtence of Butter, which is the fat part of Milk, that is, of a liquor half-changed into an animal juice.

This explication furniſhes us alſo with the reaſon why Acids agree ſo ill with people of weak and delicate conſtitutions. The motion and heat in their bodies is not ſufficient to effect a due combination of the Acids with the Oils. Hence it comes to paſs, that, during and after digeſtion, they find in their bowels the bad effects of thoſe Acids, in the diſorder commonly called the *Heart-burn.* Hence alſo it is that ſuch people receive great benefit from the uſe of Abſorbents, which uniting with the Acids neutralize them, and relieve nature when ſhe has not ſtrength enough herſelf to get the better of them.

To return to our analyſis of Butter: we took notice in the proceſs that Butter ſeems to boil with a very moderate heat at the beginning of the diſtillation, and that in the courſe of the operation the ebullition ceaſes entirely, though the heat be then greatly increaſed; which is contrary to the general rule. The reaſon is, that butter, though a ſeemingly homogeneous maſs, contains nevertheleſs ſome particles of Cheeſe and Whey. The particles of Whey, being much the lighteſt, endeavour, on the firſt application of heat, to extricate themſelves from amongſt the particles of Butter, and to riſe in diſtillation. Thus they form the drops of acidulated phlegm which come over at firſt, and, in ſtruggling to get free, lift up the buttery parts, or actually boil, which occaſions the ebullition obſervable at the beginning of the proceſs. When they are once ſeparated, the melted Butter remains calm and ſmooth without boiling. If you want to make it boil you muſt apply a much greater degree of heat; which you cannot do in cloſe veſſels, without ſpoiling the whole operation: becauſe the degree of heat neceſſary for that purpoſe would force up the Butter in ſubſtance, which would ruſh over into the receiver, without any decompoſition. Indeed if the veſſels were luted they would be in danger of burſting.

As to the caſeous parts, which are mixed with freſh Butter, they alſo ſeparate at the beginning of the diſtillation, when the Butter is melted, and gather on its ſurface in a ſcum. Theſe particles of Cheeſe and Whey, which are heterogeneous to Butter, help to make it ſpoil the ſooner. And for this reaſon thoſe who want to keep Butter a long time, without the uſe of ſalt, melt it, and thereby evaporate the aqueous parts. The lighteſt portion of the particles of Cheeſe riſes to the ſurface, and is ſkimmed off; the reſt remains at the bottom of the veſſel, from which the Butter is eaſily ſeparated, by decanting it while it is yet fluid.

Butter may alſo be diſtilled, by incorporating it with ſome additament which will yield no principle itſelf, nor retain any of thoſe of the Butter. I have diſtilled it in this manner with the additament of fine ſand: the operation ſucceeds very well, is ſooner finiſhed, and more eaſily conducted: but I choſe to deſcribe here the manner of doing it without additament; becauſe the ſeveral changes, which the Butter undergoes in the retort during the operation, may be better obſerved.

If you deſire to convert the Butter wholly into Oil, you muſt take the fixed matter you find in the receiver, and diſtil it once more, or oftener, according to the degree of fluidity you want to give it. The caſe is the ſame with this matter as with all other thick Oils, which, the oftener they are diſtilled, grow always the more fluid, becauſe in every diſtillation they are ſeparated from part of the Acid, to which alone they owe their conſiſtence.

PROCESS III.

The Curd of Milk analyzed by diſtillation.

INTO a glaſs retort put ſome new Curd, having firſt drained it thoroughly of all its Whey, and even ſqueezed it in a linen cloth to expreſs all its moiſture Diſtil it as you did Butter There will come over at firſt an acidulated phlegm, ſmelling like Cheeſe or Whey. As the diſtillation advances, the Acidity of this phlegm will increaſe.

When it begins to run but very ſlowly raiſe your fire. There will come over a yellow Oil, ſomewhat empyreumatic. Continue the diſtillation, ſtill increaſing the fire by degrees as occaſion requires. The Oil and acid Phlegm will continue to riſe; the Phlegm growing gradually more acid, and the Oil deeper coloured, and more empyreumatic. At laſt, when the retort is almoſt red-hot, there comes off a ſecond black Oil, of the conſiſtence of Turpentine, very empyreumatic, and ſo heavy as to ſink in water. In the retort will be left a conſiderable quantity of charred matter.

OBSERVATIONS.

CHEESE-CURD barely drained, till no more Whey will drip from it, is not entirely freed thereof; and for this reaſon we directed it to be preſſed in a linen cloth, before it be put into the retort to be diſtilled. Without this precaution, the remaining Whey would riſe in a conſiderable quantity on the firſt application of heat; and, inſtead of analyzing the Curd only, we ſhould at the ſame time analyze the Whey alſo. This is to be underſtood of green Curd and new-made Cheeſe; for, if it be ſuffered to grow old, it will at length dry of itſelf: but then we ſhould not obtain from it the ſame principles by diſtillation; as it corrupts and begins to grow putrid after ſome time, eſpecially if it be not mixed with ſome ſeaſoning to preſerve it.

The firſt Phlegm that riſes in this diſtillation, as in that of Butter, is a portion of the Whey that was left in the Cheeſe, notwithſtanding its being well preſſed. This Phlegm grows gradually more acid, being the vehicle of the Acids of the Cheeſe, which are forced up along with it by the fire.

The Acid obtained from this matter is leſs in quantity, and weaker, than that of Butter: and accordingly the Oil diſtilled from Cheeſe is not fixed like that of Butter. Yet it is remarkable that the laſt empyreumatic Oil, which is as thick as Turpentine, is heavier than water: a property which it probably derives from the quantity of Acid it retains.

The quantity of charred matter, which remains in the retort after the diſtillation of Cheeſe, is much greater than that left by Butter; which proves that the former contains a much greater quantity of earth. Theſe coals are exceeding difficult to burn and reduce to aſhes. I have kept them red-hot, in the open air, and in a very ſtrong fire, about ſix hours, continually ſtirring them, in order to bring the under parts to the ſurface, that they might be burnt, yet I could not conſume them entirely. They even deflagrated afterwards with Nitre, as if they had not been burnt at all; and yet, during the whole time of their calcination, there appeared conſtantly a ſmall flame, like that of charcoal, on the ſurface of the matter.

PROCESS IV.

Whey analyzed.

EVAPORATE two or three quarts of Whey almoſt to dryneſs in a *balneum mariæ*; and diſtil the extract, or reſiduum, in a retort ſet in a reverberating furnace, with degrees of fire, according to the general rule. At firſt ſome Phlegm will come over; then a lemon-coloured acid Spirit; and afterwards a pretty thick Oil. There will remain in the retort a charred matter, which being expoſed to the air grows moiſt. Lixiviate it with rain water, and evaporate the lixivium: it will yield you cryſtals of Sea-ſalt. Dry the charred matter, and burn it in the open air with a ſtrong fire, till it be reduced into aſhes. A lixivium of theſe aſhes will ſhew ſome tokens of a Fixed Alkali.

OBSERVATIONS.

MILK, as was ſaid before, ſeparates naturally and ſpontaneouſly into three ſorts of ſubſtances, the analyſes whereof being put together make a complete analyſis of this animal liquor. I know no Author that hath delivered the analyſes of Butter and Cheeſe; ſo that the proceſſes here given for analyzing theſe two ſubſtances are taken from the experiments I thought proper to make, in order to obtain the neceſſary lights in this matter. As for the analyſis of Whey, it is taken from one of Mr. Geoffroy's Memoirs, containing experiments on ſeveral animal ſubſtances, which was publiſhed in 1732. It is there ſo particularly and ſo well deſcribed, that it was needleſs for me to attempt it anew.

It will appear, on examining the three analyſes of the ſubſtances whereof Milk conſiſts, that none of them yields a Volatile Alkali: which I think very worthy of notice; as it is, I believe, the only animal matter from which ſuch a Salt cannot be obtained. It is true, the milk of animals tht feed on vegetables may be conſidered as an intermediate liquor between vegetable and animal ſubſtances; as an imperfect animal juice, which ſtill retains much of the vegetable nature: and we actually find that Milk almoſt always hath, at leaſt in part, the properties of thoſe plants with which the animals that yield it are fed. Yet, as it cannot be formed in the body of the animal, without mixing with ſeveral of its juices that are entirely perfected, and become purely animal, it muſt appear ſtrange that the analyſis thereof ſhould not afford the leaſt veſtige of that principle, which all other animal matters yield in the greateſt plenty.

I imagine the reaſon of this may be found in the uſe to which Milk is deſtined. It is intended for the nouriſhment of animals of the ſame ſpecies with thoſe in whoſe bodies it is produced. Conſequently it ought as much as poſſible to reſemble the juices of the food which is proper for thoſe animals. Now, as animals that live only on vegetables could not be properly nouriſhed by animal matters, for which nature itſelf hath even given them an averſion, it is not ſurpriſing that the Milk of ſuch animals ſhould be free from any mixture of ſuch things as are unſuitable to the young ones whom it is deſigned to nouriſh There is reaſon therefore to think that nature hath diſpoſed the organs, in which the ſecretion of Milk is performed, ſo as to ſeparate it entirely from all the animal juices firſt mixed with it: and this I take to be the principal difference between Milk and Chyle; the latter being neceſſarily blended with the ſaliva, the gaſtric and pancreatic juices, the bile and lymph, of the animals in which it is formed. Hence it may be concluded, that, if a quantity of Chyle could be collected ſufficient to enable us to analyze it, the analyſis thereof would differ from that of Milk, in this chiefly that it would yield a great deal of Volatile Alkali, of which Milk, as hath been ſaid, yields none at all.

The ſame thing probably takes place in carnivorous animals. It is certain that thoſe animals chuſe to eat the fleſh of ſuch others only as feed upon vegetables; and that nothing but extreme hunger, and the abſolute want of more agreeable food, will force them to eat the fleſh of other carnivorous animals. Wolves, which greedily devour ſheep, goats, &c. ſeldom eat Foxes, Cats, Polecats, &c. though theſe animals are not ſtrong enough to reſiſt them. Foxes, Cats, and Birds of prey, that make ſuch terrible havock among wild fowl, and other ſorts of game, do not devour one another. This being laid down, there is reaſon to think that the Milk of carnivorous animals is ſomething of the nature of the fleſh of thoſe animals that feed on vegetables, and which they chuſe to eat, and not of the nature of their own fleſh; as the Milk of animals that feed on vegetables is analagous to the juice of vegetables, and when analyzed yields no Volatile Alkali, though every other part of their body does.

But whatever be the nature of Milk, and of whatever ingredients it be formed, it always contains the three ſeveral ſubſtances above-mentioned; namely, the fat, or Buttery part, properly ſo called, the Cheeſy, and the Serous part, the laſt of which we are now examining. It is, properly ſpeaking, the Phlegm of the Milk, and conſiſts almoſt entirely of water. For this reaſon it is proper to leſſen the quantity thereof conſiderably by evaporation, ſo that its other principles, being concentrated and brought nearer together, may become much more ſenſible. There is no danger of loſing any eſſential part of the Whey in the evaporation, if it be performed in the *balneum mariæ*, with ſuch a gentle heat as may carry off the aqueous parts only: this greatly ſhortens the analyſis, which will prove exceeding long and tedious, if all the water be diſtilled off in cloſe veſſels.

As Whey is chiefly the aqueous part of Milk, as ſaid above, it muſt contain all the principles thereof that are ſoluble in water; that is, its ſaline and ſaponaceous parts. And accordingly the analyſis thereof ſhews that it contains an Oil, rendered perfectly ſaponaceous by an Acid; that is, made perfectly miſcible with water. This quality of the Oil contained in Whey appears from the perfect tranſparency of that liquor, which we know is the mark of a complete diſſolution. In the diſtillation of Whey, the ſaponaceous matter contained therein is decompoſed; the ſaline part riſes firſt, as being the lighteſt; this is the Acid taken notice of in the proceſs; after which the Oil, now ſeparated from the principle which rendered it miſcible with water, comes over in its natural form, and doth not afterwards mix with the aqueous part.

Beſides the ſaponaceous matter, Whey contains alſo another ſaline ſubſtance; namely, Sea-Salt: this is obtained by lixiviating the *caput mortuum* left in the retort, which, becauſe of its fixedneſs, cannot riſe with the other principles in diſtillation. To this Salt it is owing that what remains in the retort after diſtillation grows moiſt in the air; for we know that Sea-ſalt thoroughly dried hath this property.

The fixed Alkaline Salt, obtained from the *caput mortuum* burnt to aſhes, proves that Milk ſtill retains ſomething of the vegetable nature: for the following analyſis will ſhew us that matters purely animal yield none at all.

CHAP. II.

Of the SUBSTANCES *which compoſe an* ANIMAL BODY.

PROCESS I.

Blood analyzed. Inſtanced in Bullock's Blood.

IN a *balneum mariæ* evaporate all the moiſture of the Blood that the heat of boiling water will carry off. There will remain an almoſt dry matter. Put this dried Blood into a glaſs retort, and diſtil with degrees of heat, till nothing more will come over, even when the retort is quite red-hot, and ready to melt. A browniſh phlegm will riſe at firſt: this will ſoon be impregnated with a little Volatile Alkali, and then will come over a yellow Oil, a very pungent Volatile Spirit, a volatile Salt in a concrete form, which will adhere to the ſides of the receiver; and, at laſt, a black Oil, as thick as pitch. There will be left in the retort a charred matter, which being burnt yields no Fixed Alkali.

OBSERVATIONS.

BLOOD, which is carried by the circulation into all the parts of the animal body, and furniſhes the matter of all the ſecretions, muſt be conſidered as a liquor conſiſting of almoſt all the fluids neceſſary to the animal machine: ſo that the analyſis thereof is a ſort of general, though imperfect, analyſis of an animal.

Blood drawn from the body of an animal, and ſet by in a veſſel, coagulates as it grows cold; and ſometime afterwards the *coagulum* diſcharges a yellowiſh *Serum* or lymph; and in the midſt thereof ſwims the red part, which continues curdled. Theſe two ſubſtances, when analyzed, yield nearly the ſame principles; and in that reſpect ſeem to differ but little from each other. Though the Serum of Blood be naturally in a fluid form, yet it hath alſo a great tendency to coagulate, and a certain degree of heat applied to it, either by water, or by a naked fire, will curdle it. Spirit of Wine mixed with this liquor produces on it the ſame effect as heat.

Blood, while circulating in the body of a healthy animal, and when newly taken from it, hath a mild taſte, which diſcovers nothing like either an Acid or an Alkali; nor doth it ſhew any ſign of either the one or the other in Chymical trials. When taſted with attention it betrays ſomething like a ſavour of Sea-ſalt; becauſe it actually contains a little thereof, which is found in the charred matter left in the retort after diſtillation, when carefully examined.

We ſhewed that Milk alſo contains a little of this Salt. It enters the bodies of animals with the food they eat, which contains more or leſs thereof according to its nature. It plainly ſuffers no alteration by undergoing the digeſtions, and paſſing through the ſtrainers, of the animal body. The caſe is the ſame with the other Neutral Salts which have a Fixed Alkali for their baſis: we find them unchanged in the juices of animals into whoſe bodies they have been introduced. They are incapable of combining, as Acids do, with the oily parts; and ſo are diſſolved by the aqueous fluids, of which nature makes uſe to free herſelf from thoſe Salts, and diſcharge them out of the body; as ſhall be ſhewn when we come to ſpeak of Urine and Sweat.

Blood, like all other animal matters, is, properly ſpeaking, ſuſceptible of no fermentation but that of putrefaction. Yet it turns ſomewhat ſour before it putrefies. This ſmall degree of acetous fermentation is moſt ſenſible in fleſh; and eſpecially in the fleſh of young animals, ſuch as calves, lambs, chickens, &c.

The quantity of pure water, which Blood, in its natural ſtate, contains, is very conſiderable, and makes almoſt ſeven eighths thereof. If it be diſtilled, without being firſt dried, the operation will be much longer; becauſe it will be neceſſary to draw off all this inſipid phlegm with a gentle fire. There is no reaſon to apprehend that, by drying Blood in open veſſels as directed, any of its other principles will be carried off with its Phlegm: for it contains no other ſubſtance that is volatile enough to riſe with the warmth of a *balneum mariæ*. This may be proved by putting ſome undried Blood into a glaſs cucurbit, fitting thereto a head and receiver, and diſtilling, in a *balneum mariæ*, all that the heat of the bath, not exceeding the heat of boiling water, will raiſe: for, when nothing more will come over, you will find in the receiver an inſipid phlegm only, ſcarce differing from pure water, except in having a faint ſmell like that of Blood; wherein it reſembles all the phlegms that riſe firſt in diſtillation, which always retain ſomething of the ſmell of the matters from which they were drawn. That part of the Blood, which remains in the cucurbit after this firſt diſtillation, being put into a retort, and diſtilled with a ſtronger fire, yields exactly the ſame principles, and in the ſame proportion, as Blood dried in open veſſels in the *balneum mariæ*: ſo that, if this Phlegm of Blood contain any principles, the quantity thereof is ſo ſmall as to be ſcarce perceptible.

The Volatile Alkali that riſes with the Oil, when Blood is diſtilled in a retort with a degree of heat greater than that of boiling water, is either the production of the fire, or ariſes from the decompoſition of an Ammoniacal Salt, of which it made a part. For we ſhall ſee, when we come to treat of this ſaline ſubſtance, that it is ſo extremely volatile as to exceed, in that reſpect, almoſt all other bodies that we know: and therefore if this Volatile Alkali pre-exiſted formally in the Blood, uncombined with any other matter capable, in ſome meaſure, of fixing it, it would riſe at firſt almoſt ſpontaneouſly, or at leaſt, on the firſt application of the gentleſt heat. We have an inſtance of this in Blood, or any other animal matter, that is perfectly putrefied; which containing a Volatile Alkali, either formed or extricated by putrefaction, lets go this principle when diſtilled, even before the firſt phlegm: and, for this reaſon, when putrefied Blood is to be analyzed, it muſt by no means be dried, like freſh Blood, before diſtillation; for all the Volatile Alkali would by that means be diſſipated and loſt at once.

The Volatile Alkali obtained from Blood that hath not undergone putrefaction, affords matter of ſome ſpeculation. Indeed the ſeparation of this Salt from Blood requires a degree of heat, vaſtly greater than that which is neceſſary to make it riſe, when it is perfectly formed and diſentangled: and this gives room to think that it is the reſult of a combination formed by the fire, during the diſtillation. But then this ſame degree of heat neither ſeparates nor forms any Volatile Alkali in a great number of plants, or in milk, as hath been ſhewn. Yet it cannot be ſuppoſed that the blood of animals, which feed only on thoſe plants or on milk, is any other than theſe very matters digeſted and rendered perfectly animal ſubſtances: whence it muſt be concluded, that, when vegetable ſubſtances are converted into animal ſubſtances, they undergo ſuch alterations as render them capable of yielding, when analyzed, a principle that was not diſcoverable in them before. Now we know that this ſame principle, that is, the Volatile Alkali, is the product of putrefaction, or, which is the ſame thing, of the laſt degree of fermentation: and this, I think, makes the opinion of thoſe more than probable, who believe that trituration and mechanical motion are not the only cauſes, that effect the converſion of food into an animal juice, but that fermentation hath a great ſhare in this change. It is true, we do not find, in animal matters, any manifeſt token of an Ardent Spirit, an Acid, or a Volatile Alkali; nor, conſequently, any ſubſtance that is an evident production of any of the three different degrees of fermentation: and yet, as ſubſtances perfectly animalized are exactly in the ſame ſtate with vegetables that have undergone the firſt, and even the ſecond, degree of fermentation, ſo that they are ſuſceptible of putrefaction only; (or, at leaſt, if they ſhew at firſt ſome faint tokens of acidity, they run immediately and rapidly into complete putrefaction); it is nevertheleſs probable, that vegetable matters, in order to their becoming animal ſubſtances, undergo certain changes and alterations, which have ſome reſemblance with thoſe produced by fermentation.

This opinion is further confirmed by two other analogies, between animal matters, and vegetables advanced to the laſt ſtage of fermentation; which is, that they yield neither an Eſſential Oil nor a Fixed Alkali: for the coal, that remains in the retort after the diſtillation of Blood, being burnt in an open fire, diſcovers no Fixed Alkali in its aſhes.

The want of a Fixed Alkali in animal matters ariſes from hence, that their Acid is nearly in the ſame ſtate with the Acid of vegetable matters which have undergone putrefaction; that is, it is ſo ſubtilized and attenuated, as to be fit to enter into the combination of a Volatile Alkali, and is no longer ſo intimately united with the fixed earth as to produce therewith a Fixed Alkali in the fire.

Though Blood and other animal matters afford no Fixed Alkali, but, on the contrary, yield much Volatile Alkali, it doth not therefore follow that all the Acid, which thoſe ſubſtances contained before they were analyzed, is employed in the production of a Volatile Alkali. We ſhall hereafter take notice of an animal matter which contains a great deal of Acid: and, not to depart from our preſent ſubject, it doth not appear to me to be a ſettled point among Chymiſts, whether or no Blood, when analyzed, yields a portion manifeſtly acid, and poſſeſſing all the properties of an Acid.

Mr. Boerhaave, with ſome other Chymiſts, makes no mention of any Acid in his analyſis of Blood. Mr. Homberg, on the contrary, ſays * expreſly, that he conſtantly ob-

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* Memoirs of the Academy of Sciences for 1712.

tained an Acid from the Blood and fleſh of different ſorts of animals, of which he analyzed a great number. Mr. Boerhaave's authority is very reſpectable, and of great weight: on the other hand, Mr. Homberg's experiments are very concluſive, ſeem to be made with great care, and are all affirmative. This apparent diverſity in the ſame analyſis, delivered by theſe two great men, determined me to analyze Blood myſelf, and to examine ſcrupulouſly all the principles I could obtain from it.

I therefore diſtilled ſome Bullock's Blood in a retort with degrees of fire. Some Phlegm came over firſt, and then a Volatile Spirit. I changed my receiver; and on increaſing the fire there aroſe, with the Volatile Spirit, a yellow Oil, a Volatile Salt in a concrete form, a ruſſet liquor which ſmelled ſtrong of Volatile Alkali, and ſeemed at firſt to be only a Spirit impregnated with much of that Salt: at laſt came a very thick fetid Oil.

In this brown liquor, which comes off towards the end of the diſtillation, Mr. Homberg affirms the Acid to be contained: but, as it certainly is replete with a Volatile Alkali alſo, he alledges that it contains, at the ſame time, both a Volatile Alkali and the animal Acid; that theſe two Salts are diſtinct from each other, and not combined together in the form of an Ammonical Salt; that each of conſequence poſſeſſes its peculiar properties; and that this liquor is at the ſame time both Acid and Alkaline; that it efferveſces with Acids, and alſo changes the blue colours of plants to red.

The Alkalline quality of this liquor is very evident, and diſcovers itſelf in every Chymical trial; but the ſame cannot be ſaid of its Acid property. I dropped ſome of it on blue paper, the colour of which did not at firſt change in the leaſt, nor acquire the fainteſt ſhade of redneſs. This experiment almoſt determined me to conclude that Mr. Homberg was miſtaken: but ſome time afterwards I perceived that the blue paper began to turn red where it had been wetted, and that the red colour grew deeper and deeper as the paper dried: and this convinced me, that this liquor actually contains an Acid, as Mr. Homberg aſſerted; but, that the Volatile Alkali in this liquor, being much more copious than the Acid, had firſt entered the paper, and hindered the Acid from turning it red as uſual; and that, as the Alkali evaporated, the Acid began to act, and produce the cuſtomary effect. Hence we ſee that the Acid of Blood, though extricated by diſtillation, is not eaſily perceived at firſt, becauſe of the great proportion of Volatile Alkali, with which the liquor containing it is impregnated. This is probably what prevented its being diſcovered by ſeveral Chymiſts, who, it ſeems, did not ſuſpect its exiſtence, and therefore did not look for it.

Mr. Homberg takes no notice of this little difficulty in his Memoir: but he relates an experiment which might have given occaſion to ſuſpect it. It is in his analyſis of Human Blood. As the Acid in Human Blood is in leſs quantity, and leſs perceptible, than in the Blood of animals that live wholly on vegetables, he directs a ſecond diſtillation of the brown liquor, which contains at once both the Volatile Alkali and the Acid, till very little thereof be left in the retort. *This reſiduum*, ſays he, *contains a very perceptible and diſtinct Acid.* There is reaſon to believe, from Mr. Homberg's directing the ſaline liquor to be diſtilled again, that he did not find the Acid ſufficiently perceptible in it at firſt. Now a ſecond diſtillation is a very good way to render it much more ſenſible. For though this animal Acid be volatile, the Volatile Alkali is ſtill vaſtly more ſo; and therefore if the liquor containing both theſe ſaline ſubſtances be diſtilled, the Volatile Alkali muſt needs riſe firſt, and leave the Acid alone, or almoſt alone, at the bottom of the retort. This is exactly the caſe in our experiment on blue paper; the operation being here performed with a ſmall quantity, and much more expeditiouſly, as appears from our account of it.

It is not at all ſurpriſing that the Volatile Alkali and animal Acid, though confounded in the ſame liquor, ſhould not be united together and converted into a Neutral Ammoniacal Salt. Mr. Homberg pretends that theſe two ſaline matters do not act upon each other, becauſe they are too much dephlegmated. The oily parts, with which they are both loaded, may alſo contribute thereto: nor is this unprecedented; the ſame thing being obſerved of the Acid and the Volatile Alkali of ſeveral vegetable ſubſtances.

Mr. Homberg, juſtly ſuſpecting that there might be ſome difference between the condition of the Acid in the Blood of animals that feed altogether on vegetables, and that in the blood of thoſe that feed only on fleſh, examined likewiſe, by decompoſition, the Blood and the fleſh of ſome carnivorous animals. In theſe alſo he found an Acid; and it doth not appear that he obſerved any great difference, in this reſpect, between their Blood and that of other animals. The difference he found between the Blood of young, and that of grown, or old, animals, with reſpect to the Acid, ſeems, by his account, to be more conſiderable; the Blood of the former containing much more of it than that of the latter: and this is ſo much the more probable, as we know that the fleſh of young animals grows ſour, before it putrefies, more ſenſibly than that of old ones.

We ſhall conclude this head with a remark concerning the management required in diſtilling Blood. When the operation is advanced to a certain point, the matter contained in the retort often ſwells ſo as to ſtop the neck of that veſſel entirely, and by that means makes it burſt with an exploſion. To avoid this inconvenience, a very ſmall quantity of Blood muſt be put into the retort, and the fire muſt be governed very warily. I have alſo found that this accident may generally be prevented by mixing the Blood with ſome matter that can afford no principle by diſtillation; ſuch as pounded glaſs or fine ſand.

PROCESS II.

Fleſh analyzed. Inſtanced in Beef.

INTO an alembic or retort, placed in a ſand-bath, put ſome lean Beef, from which you have carefully ſeparated all the fat. Diſtil till nothing more will riſe. In this firſt diſtillation a phlegm will come over, weighing at leaſt half the maſs of the diſtilled fleſh. In the retort you will find a matter almoſt dry, which you muſt afterwards diſtil, with a naked fire, in a reverberating furnace, taking the uſual precautions. There will come over at firſt a little phlegm replete with Volatile Alkali; then a Volatile Alkali in a dry form, which will ſtick to the ſides of the veſſel; and alſo a thick Oil. After the diſtillation there will be left in the retort a black, ſhining, light coal. Burn it to aſhes in the open air, and lixiviate thoſe aſhes: the water of the lixivium will have no Alkaline property, but will ſhew ſome tokens of its containing a little Sea-ſalt.

OBSERVATIONS.

THIS analyſis of Beef is taken from a Memoir given in by Mr. Geoffroy in 1730, the purpoſe of which was a Chymical examination of the meat commonly uſed to make broth. The fleſh of an animal, as appears from the proceſs, yields much the ſame principles with its Blood: and it cannot be otherwiſe; becauſe it is formed all together of materials furniſhed by the Blood.

Mr. Geoffroy obſerves, that the firſt phlegm, drawn off from it in the *balneum mariæ*, produces a white precipitate in a ſolution of Corroſive Sublimate; which ſhews it to contain a little Volatile Alkali: but the quantity thereof muſt be very ſmall; ſeeing the phlegm that contains it ſmells only like broth, and not like a Volatile Alkali; one particle of which, we know, is capable of affecting the organ of ſmelling very ſenſibly. As to the Acid of fleſh, there is great reaſon to believe that it is conditioned exactly like that of Blood.

The aſhes of the *caput mortuum* of fleſh, burnt in an open fire, attract the moiſture of the air, as Mr. Geoffroy remarks, and increaſe in weight, though they contain no Fixed Alkali. However, this is not at all ſurpriſing; ſince they contain ſome Sea-ſalt, the known property whereof is to grow moiſt in the air.

The fleſh of animals contains much matter that is ſoluble in water. Mr. Geoffroy examined ſeparately that part of fleſh which water is capable of diſſolving. With this view he boiled four ounces of beef with three pints of water, in a very cloſe veſſel, and repeated the operation ſix times with equal quantities of freſh water; in order to extract, as far as poſſible, all the juices of the meat. Theſe broths he put all together, the laſt of them having but a faint ſmell of very weak veal broth: he evaporated them over a ſlow fire, filtering them towards the end of the evaporation, to ſeparate an earthy part; and there remained in the veſſel a moderately ſolid extract, which ſoon grew moiſt in the air. This extract, being analyzed, yielded a dram and two grains of Volatile Salt, which adhered to the ſides of the receiver; not in ramifications, as Volatile Salts uſually do, but in flat cryſtals, moſtly in the form of parallelopipeds. The Spirit and the Oil, which came over together after the Volatile Salt, weighed thirty-eight grains. Salt of Tartar being mixed with this Volatile Salt ſeemed to increaſe its ſtrength; which gives room to ſuſpect that the latter contains an Ammoniacal Salt.

The charred matter left in the retort weighed but ſix grains. Its lixivium gave ſome tokens of Sea-ſalt, by making a white precipitate in a ſolution of quick-ſilver. The maſs of fleſhy fibres, that was exhauſted by boiling, being dried and analyzed in the ſame manner, yielded a Volatile Spirit, a Volatile Salt in a concrete form, which ſtuck to the ſides of the receiver in ramifications as uſual; and a thick fetid Oil. There now remained in the retort a charred matter, which being burnt in the open air or not burnt, ſhewed not the leaſt ſign of its containing any ſaline matter.

This method of analyzing fleſh, by boiling it at firſt in water, in order to extract all that can be diſſolved by this menſtruum, ſhews us that animal fleſh contains an Oil, which is in a ſaponaceous ſtate: for the extract made therefrom, by water, yields in diſtillation a conſiderable quantity of Oil, which was perfectly diſſolved in the water, while that extract was in the diluted ſtate of broth, and before it was analyzed.

It is remarkable that the Volatile Salt, yielded by the extract of fleſh, is different from that which is obtained out of the fleſh itſelf, when nothing hath been extracted from it. This Salt, as Mr. Geoffroy obſerved, differs from the common Volatile Alkalis in the form of its cryſtals; which made that Chymiſt juſtly conſider it as a Salt of a ſomewhat Ammoniacal nature; a kind of Eſſential Salt of fleſh.

There is reaſon to think that this Salt, when diſſolved in the water in which we boil fleſh, is ſeparated therefrom, by the action of fire, with more eaſe than while it remains combined with the other principles, in the ſubſtance of the fleſh; that its ſeparation, in the latter caſe, requiring a greater degree of heat, it is thereby decompoſed; and that the Volatile Alkali, which is obtained from fleſh diſtilled in the uſual manner, is only one of the parts that conſtituted the Ammoniacal Salt thereby decompoſed.

The charred matter remaining, after the diſtillation of fleſh firſt exhauſted by boiling, yields nothing ſaline; becauſe the Sea-ſalt, which is the only Fixed Salt it could contain, was diſſolved by the water together with the matter of the extract.

Mr. Geoffroy likewiſe examined what parts of fleſh Spirit of Wine is capable of diſſolving. For this purpoſe he took four ounces of Beef, dried in the *balneum mariæ*, poured on it an equal weight of well rectified Spirit of Wine, and left the whole in digeſtion for a conſiderable time. The Spirit extracted from the Beef a weak tincture, and ſeparated from it ſome drops of Oil: it acquired a brown colour, and a faint ſmell. Mr. Geoffroy found, by ſeveral experiments, that the Spirit of Wine had taken up a portion of the Ammoniacal, or Eſſential, Salt of the fleſh. With reſpect to the Oil, if any at all were diſſolved, it could be but very little; for that which the Spirit ſeparated, and which retained its natural form, was certainly not diſſolved: ſeeing in that caſe it would not have been perceived, but would have made a homogeneous liquor, to appearance, with the Spirit of Wine.

PROCESS III.

Bones analyzed. Inſtanced in Ox-bones.

CUT into pieces the Bones of a leg of beef, carefully ſeparating all the marrow. Put them into a retort, and diſtil them in a reverberating furnace, as uſual. A phlegm will come over firſt; then a Volatile Spirit, which will become ſtronger and ſtronger; afterwards a Volatile Salt in a dry form, with ſome Oil; and, laſtly, a black Oil, with a little more Volatile Salt. There will be left in the retort a charred matter, from which a little Sea ſalt may be extracted. Reduce this charred matter to aſhes, by burning it in the open air. Theſe aſhes will give ſome ſlight tokens of a Fixed Alkali.

OBSERVATIONS.

THE analyſis of Bones proves that they conſiſt of the ſame principles with fleſh and blood; and the ſame may be ſaid, in general, of all matters that are truly animal, or that actually conſtitute any part of an animal.

Nevertheleſs, we find in the aſhes of Bones ſomewhat of an Alkaline quality; ſeeing they make a red precipitate in a ſolution of Corroſive Sublimate: and yet a true Fixed Alkali cannot be obtained from them. Theſe aſhes are probably in the ſame caſe with quick lime; which hath certain properties of Alkaline Salts, though no Salt of that kind can be extracted from it.

Mr. Geoffroy analyzed Bones in the ſame manner as he did fleſh; that is, he at firſt made a ſtrong decoction of them with water, and then examined and diſtilled apart the extract afforded him by that decoction, and the Bones deprived of that extract. On this analyſis he made two remarkable obſervations.

The firſt is, that Bones yielded to boiling water their principles and their Volatile Salts, both ſooner and more copiouſly than fleſh did: for in the analyſis which Mr. Geoffroy made of ſeveral ſorts of fleſh, though he robbed them in a manner of all their principles by boiling, yet their dried fibres afterwards yielded a conſiderable quantity of Volatile Salt; whereas the Bones, of which he had made an extract by boiling, afforded him but a very ſmall quantity thereof when analyzed.

The ſecond obſervation worthy of notice which Mr. Geoffroy made on his analyſis of Bones is this; the Salt, which, as was ſhewn in the analyſis of fleſh, was reſolved by the water wherein he boiled the fleſh, and conſequently aroſe when he diſtilled the extract obtained from that decoction, and cryſtallized in the form of parallelopipeds, took a quite different turn in the analyſis of Bones. None of it appeared in diſtilling the extract made by decoction, but aroſe in diſtilling the boiled Bones, that were exhauſted of almoſt all their other principles by the decoction with water. Theſe differences probably ariſe from the different contexture of the animal matters in which they are obſerved.

This analyſis of Bones may ſerve as a pattern for analyzing all the ſolid parts of animals, ſuch as horns, hoofs, ivory, &c.

PROCESS IV.

Animal Fat analyzed. Inſtanced in Mutton-Suet.

PUT as much Mutton-Suet as you pleaſe into a glaſs retort, only taking care that the veſſel be but half-full; and diſtil with degrees of fire as uſual. A phlegm ſmelling of the Suet will riſe firſt, and ſoon grow very acid. After this ſome drops of Oil will come over, and be followed by a matter like Oil, in appearance, when it comes over; but it will fix in the receiver, and acquire a conſiſtence ſomewhat ſofter than Suet. This kind of Butter of Suet will continue to riſe to the end of the diſtillation; and there will be left in the retort a ſmall quantity of charred matter.

OBSERVATIONS.

THOUGH animal Fat be a ſubſtance that hath paſſed through all the ſtrainers of the body; though it hath undergone all the elaborations neceſſary to form an animal matter, and become itſelf part of the animal: it contains, nevertheleſs, as its analyſis ſhews, principles differing greatly from thoſe of all other animal matters: ſo that it muſt be claſſed, in ſome ſort, by itſelf.

It conſiſts almoſt entirely of Oil: but this Oil is in a concrete form, and obſerves the general rule of all concreted oily matters, which owe their conſiſtence wholly to the Acid that is combined with them. The rule is evidently ſo general, that it extends even to the animal kingdom, where, in all other inſtances, Acids ſeem to be almoſt annihilated.

All we ſaid above on the ſubject of Butter muſt be applied here: for animal Fat, properly ſo called, and Butter, do not, in my opinion, differ ſenſibly from each other, with reſpect to their analyſis. And therefore there is great reaſon to believe, that what is Butter in Chyle, or Milk, becomes Fat when fixed in the animal body. It is a kind of repoſitory, in which nature lays up and confines the Acid that is unneceſſary to the animal compoſition, and which ſhe could not any other way eliminate.

I made choice of Mutton-Suet for an inſtance of the analyſis of Fat; becauſe this Fat, being the firmeſt of any, muſt contain a ſtronger and more perceptible Acid.

When it is thus diſtilled, the part which remains fixed hath much leſs conſiſtence than the Suet had before; which ariſes from its having loſt part of its Acid. Repeated diſtillations will deprive it of a much greater quantity thereof, and ſo reduce it into an Oil that will always remain clear and fluid.

Not one particle of Volatile Alkali is obtained by diſtilling Suet: but then the experiment will not ſucceed as it ought, unleſs care be taken to free the Suet perfectly from all the membranes, and all the particles of fleſh and blood that may be mixed with it; for, if it ſhould be diſtilled without this precaution, thoſe heterogeneous matters mingled with it would yield a great deal of Volatile Alkali in diſtillation; which might impoſe on the Artiſt, and make him think the Salt came actually from the Suet. Suet that hath been often melted, as the tallow, for inſtance, of which candles are made, is ſufficiently purified: of this I made uſe in my analyſis, and it yielded me no Volatile Alkali; at leaſt I could perceive none.

In concluſion, all that hath been ſaid, on ſeveral occaſions, touching the properties of concreted oily matters, may be applied to Suet. I ſhall only obſerve here, that it is one of thoſe that manifeſt no Acidity, and conſequently that in its natural ſtate it is not ſoluble in Spirit of Wine, and only becomes ſoluble in that menſtruum by degrees, as its Acid is extricated by repeated diſtillations: and on this account it ought to be claſſed with Bee's-Wax, and other oily compounds of that kind.

PROCESS V.

Eggs analyzed. Inſtanced in Pullet's Eggs.

PUT ſome Hen's Eggs in water, and boil them till they be hard. Then ſeparate the Yelks from the Whites. Cut the Whites into little bits; put them into a glaſs cucurbit; fit on a head and receiver; diſtil in a *balneum mariæ* with degrees of fire, raiſing it towards the end to the ſtrongeſt heat which that bath can give; that is, to the heat of boiling water. There will come over an aqueous liquor, or inſipid phlegm; the quantity whereof will be very conſiderable, ſeeing it will make about nine-tenths of the whole maſs of the Whites of the Eggs. Continue your diſtillation, and keep the water in the bath conſtantly boiling, till not a drop more of liquor will aſcend from the alembic. Then unlute your veſſels. In the cucurbit you will find your Whites of Eggs conſiderably ſhrunk in their bulk. They will look like little bits of brown glaſs, and be hard and brittle.

Put this reſiduum into a glaſs retort, and diſtil, as uſual, in a reverberating furnace with degrees of heat. There will come over a Volatile Oily Spirit, a yellow Oil, a Volatile Salt in a dry form, and, at laſt, a black thick Oil. There will be left in the retort a charred matter.

Reduce alſo into the ſmalleſt pieces you can the hard Yelks of the Eggs which you ſeparated from the Whites. Set them in a pan over a gentle fire: ſtir them with a ſtick till they turn a little brown, and diſcharge a ſubſtance like melted marrow. Then put them into a new ſtrong canvaſs bag, and preſs them between two iron plates well heated; whereby you will obtain a conſiderable quantity of a yellow Oil.

Let what remains in the bag be diſtilled in a retort ſet in a reverberating furnace: it will give you the ſame principles as you got from the Whites.

OBSERVATIONS.

OF the two perfectly diſtinct ſubſtances that conſtitute the Egg, the Yelk contains the embryo of the chick, and is deſtined to hatch it: the White is to ſerve for the nouriſhment of the chick when it is formed.

Theſe two matters, though they contain the very ſame principles, yet differ conſiderably from each other; and chiefly in this, that their principles are not in the ſame proportions.

The White of an Egg contains ſo much phlegm, that it ſeems to conſiſt almoſt totally thereof. All the aqueous liquor, obtained by diſtilling it in the *balneum mariæ*, is, properly ſpeaking, nothing but pure water; for no Chymical trial can diſcover in it either an Acid or a Volatile Alkali; or any very perceptible Oily part. And yet it muſt contain ſome Oil, becauſe the liquor that riſes laſt is a little bitteriſh to the taſte, and ſmells ſomewhat of empyreuma. But the principles from which it derives theſe properties are in too ſmall quantities to be diſtinctly perceived.

If, inſtead of diſtilling the hard White of an Egg, with a view to draw off the great quantity of water it contains, you leave it ſome time in an air that is not too dry, the greateſt part of its moiſture ſeparates ſpontaneouſly, and becomes very ſenſible. In all probability this is the effect of a beginning putrefaction, which attenuates this ſubſtance, and breaks its contexture. The liquor thus diſcharged by the White of an Egg thoroughly diſſolves Gum-Reſins, and particularly Myrrh. If you deſire to diſſolve Myrrh in this manner, cut a hard-boiled Egg in halves; take out the Yelk; put the powdered Gum-Reſin into the cavity left by the Yelk; join the two halves of the White; faſten them together with a thread, and hang them up in a cellar. In a few days time the Myrrh will be diſſolved by the moiſture that iſſues from the White of the Egg, and will drop into the veſſel placed underneath to receive it. This liquor is improperly called *Oil of Myrrh per deliquium*.

All the properties of the Whites of Eggs, as well as the principles obtained by analyzing them, are the ſame with thoſe of the lymphatic part of the blood; ſo that there is a great reſemblance between theſe two ſubſtances.

As to the Yelk, it is plain from its analyſis that Oil is the predominant principle thereof. If the Yelk of an Egg be mixed with water, the Oil with which it is replete, and which is by nature very minutely divided, diffuſes itſelf through the whole liquor, and remains ſuſpended therein by means of its viſcoſity. The liquor at the ſame time becomes milk-white like an emulſion, and is in fact a true animal emulſion.

In

In order to obtain the Oil of Eggs by expreſſion with the more eaſe, care muſt be taken to chuſe Eggs that are ſeven or eight days old; becauſe they are then a little leſs viſcous. Nevertheleſs, their viſcoſity is ſtill ſo great that they will not eaſily yield their Oil by expreſſion: and therefore, in order to attenuate and deſtroy entirely this viſcoſity, they muſt be torrefied before they are put to be preſſed.

The Oil of Eggs, like all other oily animal matter, ſeems analagous to the Fat Oils of vegetables. It hath all the properties that characteriſe thoſe Oils. Its colour is yellow, and it ſmells and taſtes a little of the empyreuma, occaſioned by torrefying the Yelks. It is rendered ſomewhat leſs diſagreeable by being expoſed to the dew for thirty or forty nights, if care be taken to ſtir it often in the mean time.

To conclude: all the principles, both in the Yelk and the White of an Egg, are the ſame as thoſe found in Blood, Fleſh, and all other matters that are perfectly animal.

CHAP. III.

Of the EXCREMENTS *of* ANIMALS.

PROCESS I.

Dung analyzed. Inſtanced in Human Excrement. Mr. Homberg's Phoſphorus.

TAKE any quantity you pleaſe of human Excrement, and diſtil it in a glaſs alembic ſet in the *balneum mariæ*. You will obtain an aqueous, clear, inſipid liquor; which will nevertheleſs have a diſagreeable odour. Having urged the diſtillation as far as is poſſible, with the heat of this bath, unlute your veſſels, and you will find at the bottom of the cucurbit a dry matter, making about an eighth part only of what you put into it. Put this reſiduum into a glaſs retort, and diſtil in a reverberating furnace, with degrees of heat. You will obtain a Volatile Spirit, and a Volatile Salt, with a fetid Oil; and a charred matter will be left in the retort.

OBSERVATIONS.

Mr. HOMBERG made a great many experiments on the dung of animals; concerning which he compoſed two Memoirs publiſhed in the Academy's collection for 1711. That Chymiſt tells us, that, in diſtilling Excrement, he aimed not ſo much at diſcovering the principles of which it conſiſts, as he was deſirous to ſatisfy a friend of his, who had earneſtly entreated him to try whether he could not extract therefrom a clear Oil, having no bad ſmell; becauſe he had ſeen, as he ſaid, Mercury fixed into pure Silver by ſuch an Oil.

Mr. Homberg's labour had the uſual fate of all enterpriſes of this nature He actually found the art of drawing from Excrement a clear ſcentleſs Oil; but, in whatever way he applied it to Mercury, it produced no change in that metallic ſubſtance. However, as Mr. Homberg was a man of ſagacity, and knew how to improve every hint offered by his experiments, he made ſeveral curious diſcoveries on this occaſion; of which we ſhall give a conciſe account, after we have made ſome remarks on the principles obtained from Excrement by the method deſcribed in the proceſs.

This ſubſtance, conſiſting of matters ſubject to putrefaction, hath conſtantly a fetid ſmell, like that of all putrid matters; having been for ſome time confined in a warm, moiſt place, which we know promotes putrefaction, and even quickly produces it. Yet the analyſis thereof proves that it is not putrefied, or at leaſt not entirely ſo: for all putrefied matters contain a Volatile Alkali perfectly formed and extricated; and, as this principle riſes with leſs heat than that of boiling water, it always comes over firſt in diſtillation. Now we have ſeen that, with the heat of boiling water, it parts with nothing but an inſipid phlegm, containing no Volatile Alkali: a ſure proof that the fecal matter is not completely putrefied.

There is nothing remarkable in the Volatile Salt and fetid Oil, which riſe with a degree of heat greater than that of boiling water. They are common productions, of which we have made frequent mention in ſeveral of the preceding analyſes; and therefore they need not now detain us from proceeding to give a ſummary account of Mr. Homberg's chief diſcoveries.

One of the methods by which Mr. Homberg endeavoured to obtain from Excrement a clear Oil, without any bad ſmell, was to ſeparate its earthy and groſs parts, by filtering it

it before he diſtilled it. “ For this purpoſe he diluted Excre-
“ ment newly diſcharged with hot water, uſing a quart of
“ water to an ounce of feces. Then he let the mixture ſtand
“ to cool, and, the groſs parts falling to the bottom, he
“ poured off the water by inclination. This liquor he fil-
“ tered through brown paper, and evaporated to a pellicle
“ over a gentle fire. There ſhot in it long cryſtals of four,
“ five, and ſix ſides, which Mr. Homberg thinks may be
“ called the Eſſential Salt of Excrement. They reſemble
“ Salt-petre, in ſome meaſure, and deflagrate in the fire
“ much like it; with this difference, that their flame is red,
“ and they burn ſlowly; whereas the flame of Salt-petre is
“ white and very vivid: probably, ſays Mr. Homberg, be-
“ cauſe there is too much of an oily matter in the one, and
“ leſs in the other.

“ Mr. Homberg diſtilled this Salt in a glaſs retort with
“ degrees of fire, and at laſt with a very violent one. At
“ firſt there came over an aqueous liquor, ſharp and acid,
“ which was followed by a brown fetid oil, ſmelling very
“ ſtrong of empyreuma. This diſtillation he attempted four
“ ſeveral times; and each time the matter in the retort took
“ fire, juſt when the Oil began to come off.”

The Salt which Mr. Homberg obtained from excrement is very remarkable. We ſhall have occaſion to ſpeak of it in another place, and ſhall only obſerve here, that its Nitrous character is by no means ambiguous: its deflagrating on live coals convinced Mr. Homberg of its being a true Nitre. But its conſtantly taking fire in the retort, as oft as diſtilled, is a ſure proof that it is a Nitrous Salt: for Nitre only hath the property of thus taking fire in cloſe veſſels, and making other combuſtible matters burn along with it.

The proceſs by which Mr. Homberg at laſt obtained from Excrement a clear oil without any bad ſmell is curious, and worthy of a place here; on account of the views and occaſions of reflection which it may open.

“ Mr. Homberg having tried in vain, by diſtilling Excre-
“ ment a great many different ways, to obtain from it ſuch
“ an Oil as he wanted, reſolved to employ fermentation, the
“ effect whereof is to change the diſpoſition of the princi-
“ ples of mixts. With this view he dried ſome Excrement
“ in the water-bath, and, having pulverized it, poured
“ thereon ſix times its weight of phlegm that had been ſe-
“ parated from it by diſtillation, and put the whole into a
“ large glaſs cucurbit, covered with an inverted veſſel that
“ fitted exactly into it, and was cloſe luted. This veſſel he ſet
“ in

“ in a *balneum mariæ* for ſix weeks, keeping up ſuch a gentle
“ heat as would not burn one's hand; after which he unco-
“ vered the cucurbit, and having fitted thereto a head and a re-
“ ceiver, diſtilled off all the aqueous moiſture in the *balneum*
“ *mariæ* with a very gentle heat. It had now loſt almoſt all
“ its bad ſmell, which was changed into a faint one. It
“ came over ſomewhat turbid, whereas it was very clear
“ when put into the cucurbit. Mr. Homberg found this
“ water to have a coſmetic virtue: He gave ſome of it to
“ perſons whoſe complexion, neck, and arms, were quite
“ ſpoiled, being turned brown, dry, rough, and like a gooſe
“ ſkin: they waſhed with it once a day, and, by continuing
“ the uſe of this water, their ſkin became very ſoft and
“ white.”

The dry matter, that remained in the bottom of the cucurbit after diſtillation, had loſt about a twentieth part of its weight; that is, of twenty ounces, put at one time into the cucurbit, ſomewhat leſs than nineteen ounces remained. Mr. Homberg ſuſpects that it was not ſo dry when put into the cucurbit as when it was taken out. Perhaps alſo the ſpecies of fermentation which the matter underwent had attenuated and volatalized ſome part of it; ſo that it came over with the phlegm in diſtillation. The turbidneſs of that phlegm, which was clear and limpid before, ſeems to countenance this conjecture.

“ The dry matter left in the cucurbit after the firſt diſtil-
“ lation, had not the leaſt ſmell of feces: on the contrary,
“ it had an agreeable aromatic odour; and the veſſel in which
“ Mr. Homberg had digeſted it, being left open in a corner
“ of his laboratory, acquired in time a ſtrong ſmell of
“ Ambergris. It is ſurpriſing, as Mr. Homberg juſtly ob-
“ ſerves, that digeſtion alone ſhould change the abominable
“ ſmell of Excrement into an odour as agreeable as that of
“ Ambergris.

“ This dry matter he powdered coarſely, and put two
“ ounces thereof at once into a glaſs retort, that would hold
“ about a pound or a pound and half of water. This he di-
“ ſtilled in a ſand-bath with a very gentle heat. A ſmall
“ quantity of an aqueous liquor came over firſt, and then
“ an Oil as colourleſs as ſpring-water. Mr. Homberg con-
“ tinued the ſame gentle degree of heat, till the drops began
“ to come off a little reddiſh; and than he changed the receiv-
“ er, ſtopping that which contained the clear Oil very cloſe
“ with a cork. Having carried on the diſtillation with a fire
“ gradually augmented, there came over a conſiderable

" quantity of red Oil; and there remained in the retort a " charred matter which burnt very readily."

The clear Oil, without any ill ſmell, which Mr. Homberg obtained from the fecal matter by this proceſs, was the very thing he was in ſearch of, and which he had been aſſured would convert Mercury into fine fixed Silver: yet he ingenuouſly owns, that, whatever way he applied it, he could never produce any charge in that metallic ſubſtance. We ſhall now proceed to the other diſcoveries made by Mr. Homberg on this occaſion.

In his attempt to obtain a clear Oil from Excrement, he diſtilled it with different additaments, and amongſt the reſt with Vitriol and Alum. He found that the matters left in the retort, when he made uſe of theſe Salts, being expoſed to the open air, took fire of themſelves; that they kindled combuſtible matters; in a word, that they were a true Phoſphorus, of a ſpecies different from all then known. Purſuing theſe firſt hints, he ſought and found the means of preparing this Phoſphorus by a way much more expeditious, certain, and eaſy. His proceſs is this.

" Take four ounces of Feces newly excreted: Mix there- " with an equal weight of Roch-Alum coarſely powdered: " put the whole into a little iron pan that will hold about a " quart of water, and ſet it over a gentle fire under a chim- " ney. The mixture will melt, and become as liquid as " water. Let it boil with a gentle fire, conſtantly ſtirring " it, breaking it into little crumbs, and ſcraping off with a " ſpatula whatever ſticks to the bottom or ſides of the pan, " till it be perfectly dry. The pan muſt from time to time " be removed from the fire, that it may not grow red-hot, " and the matter muſt be ſtirred, even while it is off the " fire, to prevent too much of it from ſticking to the pan. " When the matter is perfectly dried, and in little clots, let " it cool, and powder it in a metal mortar. Then put it again " into the pan, ſet it over the fire, and ſtir it continually. " It will again grow a little moiſt, and adhere together in " clots, which muſt be continually bruiſed and roaſted till " they be perfectly dry; after which they muſt be ſuffered to " cool, and then be pulverized. This powder muſt be re- " turned a third time to the pan, ſet on the fire, roaſted and " perfectly dried: after which it muſt be reduced to a fine " powder, and kept in a paper in a dry place. This is the " firſt or preparatory operation.

" Take two or three drams of this powder. Put it into " a little matraſs, the belly of which will hold an ounce or

" an ounce and half of water, and having a neck about ſix or " ſeven inches long. Order it ſo that your powder ſhall take " up no more than about a third part of the matraſs. Stop " the neck of the matraſs ſlightly with paper: then take a " crucible four or five inches deep: in the bottom of the cru- " cible put three or four ſpoonfuls of ſand: ſet the matraſs " on this ſand, and in the middle of the crucible, ſo as not " to touch its ſides. Then fill up the crucible with ſand, ſo " that the belly of the matraſs may be quite buried therein. " This done, place your crucible, with the matraſs, in the " midſt of a little earthen furnace, commonly called a *Stove*, " about eight or ten inches wide above, and ſix inches deep " from the mouth to the grate. Round the crucible put " lighted coals about half way up, and when it hath ſtood " thus half an hour, fill up with coals to the very top of the " crucible. Keep up this fire a full half-hour longer, or " till you ſee the inſide of the matraſs begin to be red. Then " increaſe your fire, by raiſing your coals above the cruci- " ble. Continue this ſtrong heat for a full hour, and then " let the fire go out.

" At the beginning of this operation denſe fumes will " riſe out of the matraſs, through the ſtopple of paper. " Theſe fumes iſſue ſometimes in ſuch abundance as to " puſh out the ſtopple; which you muſt then replace, and " ſlacken the fire. The fumes ceaſe when the inſide of the " matraſs begins to grow red; and then you may increaſe " the fire without any fear of ſpoiling your operation.

" When the crucible is ſo cold that it may be ſafely tak- " en out of the furnace with one's hand, you muſt gradual- " ly draw the matraſs out of the ſand, that it may cool ſlow- " ly, and then ſtop it cloſe with a cork.

" If the matter at the bottom of the matraſs appear to be " in powder when ſhaken, it is a ſign the operation hath " ſucceeded: but if it be in a cake, and doth not fall into " powder on ſhaking the matraſs, it ſhews that your matter " was not ſufficiently roaſted and dried in the iron pan, " during the preparatory operation."

Since Mr. Homberg, Mr. Lemeri the younger hath made a great many experiments on this Phoſphorus, which may be ſeen in the Memoirs of the Academy for 1714 and 1715. In thoſe Memoirs Mr. Lemeri hath ſhewn, that Excrement is not the only matter capable of producing this Phoſphorus with Alum; but that, on the contrary, almoſt all animal and even vegetable matters are fit for this combination; that though Mr. Homberg mixed Alum in equal quantities only with the fecal matter, it may be uſed in a much greater proportion, and, in certain caſes, will ſucceed the better; that, according to the nature of the ſubſtances to be worked on, the quantity of that Salt may be more or leſs increaſed; and that whatever is added, more than the doſe requiſite for each matter, ſerves only to leſſen the virtue of the Phoſphorus, or even deſtroys it entirely: that the degree of fire applied muſt be different according to the nature of thoſe matters; and, laſtly, that Salts containing exactly the ſame Acid with that of Alum, or the Acid of thoſe Salts ſeparated from its baſis and reduced into Spirit, do not anſwer in the preſent operation: which ſhews, ſays Mr. Lemeri, that many ſulphureous matters may be ſubſtituted for Excrement in this operation; but that there are no Salts, or very few if any, that will ſucceed in the place of Alum. Nevertheleſs, a Chymiſt, who lately communicated to the Academy a great number of experiments on this Phoſphorus, found that any Salt containing the Vitriolic Acid may be ſubſtituted for Alum.

This Phoſphorus, made either by Mr. Homberg's or by Mr. Lemeri's method, ſhines both by day and by night. Beſides emitting light, it takes fire ſoon after it is expoſed to the air, and kindles all combuſtible matters with which it comes in contact; and this without being rubbed or heated.

Meſſ. Homberg and Lemeri have given the moſt probable and the moſt natural explanation of the cauſe of the accenſion and other phenomena of this Phoſphorus. What they ſay amounts in ſhort to what follows.

Alum is known to be a Neutral Salt, conſiſting of the Vitriolic Acid and a calcareous earth. When this Salt is calcined with the fecal matter, or other ſubſtances abounding in Oil, the volatile principles of theſe ſubſtances, ſuch as their Phlegm, their Salts, and their Oils, exhale in the ſame manner as if they were diſtilled; and there is nothing left in the matraſs, when thoſe principles are diſſipated, but a charred matter, like that which is found in retorts wherein ſuch mixts have been decompoſed by diſtillation.

This remainder therefore is nothing but a mixture of Alum and charcoal. Now, as the Acid of this Salt, which is the Vitriolic, hath a greater affinity with the phlogiſton than with any other ſubſtance, it will quit its baſis to unite with the phlogiſton of the coal, and be converted by that union into a Sulphur. And this is the very caſe; of which we have certain proofs in the operation for preparing this Phoſphorus: for when, after the volatile principles of the oily matter are drawn off, the fire is increaſed, in order to combine cloſely together the fixed parts that remain in the matraſs, that is, the Alum and the charred matter, we perceive at the mouth of the matraſs a ſmall blue ſulphureous flame, and a pungent ſmell of burning Sulphur. Nay, when the operation is finiſhed, we find a real Sulphur ſticking in the neck of the matraſs; and, while the Phoſphorus is burning, it hath plainly a ſtrong ſulphureous ſmell. It is therefore certain that this Phoſphorus contains an actual Sulphur; that is, a matter diſpoſed to take fire with the greateſt eaſe. But though Sulphur be very inflammable, it never takes fire of itſelf, without being either in contact with ſome matter that is actually ignited, or elſe being expoſed to a conſiderable degree of heat. Let us then ſee what may be the cauſe of its accenſion, when it is a conſtituent part of this Phoſphorus.

We mentioned juſt now that the Acid of the Alum quits its baſis, in order to form a Sulphur by combining with the Phlogiſton of the coal. This baſis we know to be an earth capable of being coverted into Lime; and that it is actually converted into Quick-lime by the calcination neceſſary to produce the Phoſphorus. We know that new-made Lime hath the property of uniting with water ſo readily, that it thereby contracts a very great degree of heat. Now when this Phoſphorus, which is partly conſtituted of the baſis of the Alum converted into Quick-lime, is expoſed to the air, the Lime inſtantly attracts the moiſture of which the air is always full, and by this means, probably, grows ſo hot as to fire the Sulphur with which it is mixed. Perhaps alſo the Acid of the Alum is not totally changed into Sulphur; ſome part thereof may be only half-diſengaged from its baſis, and in that condition be capable of attracting ſtrongly the humidity of the air, of growing very hot likewiſe by imbibing the moiſture, and ſo of contributing to the accenſion of the Phoſphorus.

There is alſo room to think that all the Phlogiſton of the charred matter is not employed in the production of Sulphur in this Phoſphorus, but that ſome part of it remains in the ſtate of a true coal. The black colour of the unkindled Phoſphorus, and the red ſparkles it emits while burning, ſufficiently prove this. The explanation of the accenſion of this Phoſphorus, as here given by Meſſ. Homberg and Lemeri, is very ingenious, and in the main juſt; but yet, in my opinion, the ſubject deſerves a more thorough examination.

PROCESS II.

Human Urine analyzed.

PUT ſome Human Urine into a glaſs Alembic; ſet it in a water-bath, and diſtil till there remain only about a fortieth part of what you put in; or elſe evaporate the Urine, in a pan ſet in the *balneum mariæ*, till it be reduced to the ſame quantity. With this heat nothing will exhale but an inſipid Phlegm, ſmelling however like Urine. The reſiduum will, as the evaporation advances, become of a darker and darker ruſſet, and at laſt acquire an almoſt black colour. Mingle this reſiduum with thrice its weight of ſand, and diſtil it in a retort ſet in a reverberating furnace, with the uſual precautions. At firſt there will come over a little more inſipid Phlegm like the former. When the matter is almoſt dry, a Volatile Spirit will riſe. After this Spirit, white vapours will appear on increaſing the fire; a yellow oily liquor will come off, trickling down in veins; and together with this liquor a concrete Volatile Salt, which will ſtick to the ſides of the receiver. At laſt there will come over a deep-coloured fetid Oil. In the retort there will remain a ſaline earthy reſiduum, which being lixiviated will yield ſome Sea-ſalt.

OBSERVATIONS.

URINE muſt be conſidered as an aqueous liquor replete with all the ſaline matters which are of no uſe to the body, either for nouriſhment or health: it is a lixivium of animal matters, prepared by nature for diſſolving and ſeparating from them all the unneceſſary Salts. It contains a very large quantity of almoſt pure phlegm, which evaporates with the heat of a water-bath.

The reſidue of the Urine, from which this phlegm is ſeparated by the firſt diſtillation, though thereby rendered conſiderably thicker, doth not coagulate, or curdle in the leaſt, like Milk or Blood; which ſhews that it contains no parts analagous to thoſe of theſe two nutritious liquors. Yet it contains oily and ſaline parts, diſpoſed like thoſe of truly animal matters; as appears from the Spirit, the Volatile Salt, and the Oil, obtained from it by diſtillation; which are, in every reſpect, perfectly like the ſame principles yielded by other animal ſubſtances. But, if the animal that made the Urine took in with its food any of the Neutral Salts, which cannot be decompounded by digeſtion; that is, of thoſe chiefly which conſiſt of Acids and Alkalis, the Urine will contain, over and above the other parts of that animal, almoſt all the Neutral Salt that entered into its body. Accordingly human Urine is replete with a conſiderable quantity of Sea-ſalt, becauſe men eat a great deal of it. It is found, after the diſtillation of the Urine, united with the *caput mortuum* left in the retort; becauſe, being of a fixed nature, it doth not riſe with the volatile principles in diſtillation.

Beſides this Sea-ſalt, Urine contains another Salt of a ſingular nature, which cryſtallizes differently from Sea-ſalt. In this Salt, according to Mr. Marggraff's experiments mentioned on the ſubject of Phoſphorus, is contained the Acid neceſſary to produce the Phoſphorus of Urine. There is reaſon to think that this Salt is a Sea-ſalt, diſguiſed by the fat matters with which it combines during its ſtay in the animal body.

Mr. Boerhaave calls it the Eſſential Salt of Urine. If you deſire to have it by itſelf, you muſt evaporate the Urine, with a gentle heat, to the conſiſtence of freſh cream, filter it, and let it ſtand quiet in a cool place. Cryſtals will at length ſhoot therein, and adhere to the ſides of the veſſel. Theſe cryſtals are the Salt you want: they are brown and oily. If you deſire to have them purer, you muſt diſſolve them in warm water, filter the ſolution, and ſet it by to ſhoot. This operation repeated ſeveral times will render them clear and tranſparent. Mr. Schloſſer, a young and very promiſing Chymiſt, is the laſt who hath made any experiments on this curious Salt of Urine. Thoſe who are deſirous of a particular account of its properties may conſult his diſſertation, printed at Leyden in 1753, as well as Mr. Marggraff's excellent Memoirs, printed among thoſe of the Academy of Berlin.

The chief reſult of Mr. Schloſſer's experiments is, firſt, that this Salt may be obtained from recent Urine, and even in greater quantities than from putrid Urine, and that too in very little time: ſeeing it cryſtallizes in twenty-four hours, after due evaporation.

Secondly, that this Salt is a Neutral Ammoniacal Salt, conſiſting of a Volatile Alkali, (which can never be extracted from it but in a liquid form, like that which is ſeparated from Urine by the addition of Lime); and of an Acid of a very ſingular nature, the moſt remarkable property of which is, its being ſo fixed as to reſiſt the violence of fire, and turn into a ſort of glaſs rather than exhale in vapours. This is that Acid which, according to Mr. Marggraff's experiments, forms the combination of Phoſphorus when united with the Phlogiſton. The other properties of this ſingular Acid are the principal objects of Mr. Marggraff's inquiries.

It follows, in the third place, from Mr. Schloſſer's experiments, that this Acid, being combined to the point of ſaturation with a common Volatile Alkali, forms a true, regenerated Salt of Urine; and that, by this union, the nature of the Volatile Alkali is ſo changed, that it cannot afterwards appear by itſelf in a concrete form, but is always fluid, like that which is extricated by the additament of lime.

If Fixed Alkalis be mixed with freſh Urine, they immediately ſeparate from it a Volatile Alkali; and, if the mixture be quickly put into an alembic, and diſtilled, the firſt liquor that riſes is a Volatile Spirit: or elſe a Volatile Alkali in a concrete form will riſe firſt, provided the Fixed Alkali made uſe of be not liquid, and the Urine be dephlegmated.

Herein Urine reſembles other animal matters: for Fixed Alkalis produce the ſame effect on them. This affords us good grounds for believing that all animal matters contain a Neutral Salt of an Ammoniacal nature, which the Fixed Alkali decompoſes, as it doth all other Ammoniacal Salts. Quick-lime alſo extricates from Urine a Volatile Alkali, ſtill more quick and pungent than that which is ſeparated by a Fixed Alkali, and which conſtantly remains liquid without ever putting on a concrete form: and this is another proof of the exiſtence of the Ammoniacal Salt above-mentioned; for quick-lime hath juſt the ſame effect on Sal-Ammoniac, as we ſhall ſee in its place. Mr. Schloſſer's experiments, compared with thoſe now mentioned, ſeem to ſhew that the Urine contains ſeveral diſtinct ſorts of Ammoniacal Salts.

Of all the liquors which animals afford, Urine putrefies the moſt eaſily, and by putrefaction parts with, or forms, the greateſt quantity of Volatile Alkali. If it be diſtilled when putrefied, there comes over firſt a Spirit impregnated with much Volatile Alkali; then an aqueous liquor, which Van Helmont aſſures us is a medicine of wonderful efficacy in diſſolving the ſtone in the bladder. When all this water is come over, and the remaining matter is almoſt dry, there aſcends, on increaſing the fire, a yellow Oil, together with a Volatile Salt.

After this there remains in the retort a black charred earthy matter, containing a great deal of Sea-ſalt. If this matter be calcined in the open air, in order to conſume its Phlogiſton, and be afterwards lixiviated, all the Sea-ſalt it contains may by this means be eaſily ſeparated; nothing but its earth being left behind. This *caput mortuum* contains alſo the materials proper for forming Kunckel's Phoſphorus; and if, inſtead of calcining it in the open air, it be urged with a violent fire, in cloſe veſſels, it will yield a Phoſphorus: but then all the precautions recommended on the ſubject of Phoſphorus muſt be uſed; and, in particular, the *caput mortuum* muſt be lixiviated before it be diſtilled, in order to free it from part of the Sea-ſalt contained therein; becauſe too much of that Salt might defeat the operator, by not only melting itſelf, but melting alſo the containing veſſel during the operation.

CHAP. IV.

Of the VOLATILE ALKALI.

PROCESS I.

Volatile Alkalis rectified and depurated.

MIX together the Spirit, the Volatile Salt, the Phlegm, and the Oil, obtained from any ſubſtance whatever. Put the whole into a large wide-mouthed glaſs body, and thereto fit a head with a large beak. Set this alembic in a water-bath, lute on a receiver, and diſtil with a very gentle heat. There will aſcend a Spirit, ſtrongly impregnated with a Volatile Alkali, and a Volatile Salt in a concrete form, which muſt be kept by itſelf. Then increaſe your heat to the degree of boiling water; whereupon there will riſe a ſecond Volatile Spirit, ſomewhat more ponderous than the former, with a light Oil that will ſwim on its ſurface, and a little concrete Volatile Salt. Proceed till nothing more will riſe with this degree of heat. Keep by itſelf what came over into the receiver. At the bottom of the cucurbit you will find a thick fetid Oil.

Into ſuch another diſtilling veſſel put the Spirit and Salt that roſe firſt in this diſtillation, and diſtil them in the *balneum mariæ* with a heat ſtill gentler than before. A whiter, purer, Volatile Salt will ſublime Continue the diſtillation till an aqueous moiſture riſe, which will begin to diſſolve the Salt. At the bottom of the veſſel will be left a phlegm, with a little Oil floating on it. Keep your Salt in a bottle well ſtopped.

OBSERVATIONS.

In the analyſis of any ſubſtance that yields a Volatile Alkali, this Salt is generally found in the receiver, blended with the other principles of the mixt; which, aſcending from the retort in the form of liquors and vapours, diſſolve the Salt, or at leaſt moiſten it, and render it very impure. So that, if you deſire to have it without any mixture, recourſe muſt be had to a ſecond diſtillation, in order to ſeparate it from the heterogeneous matters with which it is confounded.

It is of conſequence in this diſtillation to apply but a very weak degree of heat; becauſe on that depends the ſucceſs of the operation, inſomuch that, the leſs heat you employ to ſublime the Salt, the purer it will be. For, being far more volatile than any of the other principles with which it is mixed, it muſt evidently riſe by itſelf, if no more heat be applied than is juſt neceſſary to elevate it; ſuch a heat being much too weak to raiſe the Oil and phlegm with which it is blended.

Nevertheleſs, whatever care be taken to govern the heat, it is not poſſible to hinder this Volatile Salt from carrying up ſome portions of the principles mixed with it; thoſe, to wit, with which it is moſt cloſely united, and to which it hath by that means communicated a ſhare of its volatility. For this reaſon it requires a ſecond rectification, which is performed in the ſame manner as the former. But, ſeeing it is more volatile and lighter after the firſt rectification than before, being thereby freed from part of the heterogeneous matters with which it was loaded, a ſtill leſs degree of heat muſt be applied in this ſecond rectification.

The Oil with which the Volatile Salt is loaded, when but once diſtilled, is perceivable only by the yellow colour and weight it communicates thereto; becauſe it is cloſely united therewith, and in a perfectly ſaponaceous ſtate. This appears from the facility with which Volatile Salts, even the moſt oily, diſſolve in water, without diſcovering in the ſolution any ſeparation of the oily parts, and even without giving it a milky colour. But, in the ſecond rectification, this Oil becomes very perceptible; for it then ſeparates, in a great meaſure, from the Salt, and remains at the bottom of the cucurbit, floating on the phlegm, which is alſo ſeparated from the Salt.

The Salt is then whiter, more volatile, and purer; yet it is ſtill far from being brought to the utmoſt degree of purity, even by this ſecond rectification. It requires a third, a fourth, and even many more rectifications, to purify it perfectly: every rectification ſeparates from it ſome oily particles: and if you ſhould reſolve to go on rectifying till you can ſeparate no more Oil, there is reaſon to think this Salt would be entirely decompoſed; becauſe there is neceſſarily a certain quantity of Oil in its compoſition, without which it would not be a Volatile Alkali. You muſt therefore deſiſt from rectifying it any further, when you find it very white, and very light; and ſhut it up in bottles hermetically ſealed.

It often happens that Volatile Salts, though of a beautiful white after rectification, grow yellow after being kept ſome time in cloſe bottles. This is occaſioned by the Oil they contain diſengaging, and diſcovering itſelf by degrees. To remedy this inconvenience, Mr. Boerhaave propoſes to mingle the Volatile Salt, which you intend to purify, with four times its weight of pulverized chalk, thoroughly dried, and even heated; to put the mixture into a glaſs alembic, and diſtil it with a gentle heat. By this means the Salt riſes exceeding pure and very white; becauſe the chalk abſorbs moſt of its Oil, and frees it therefrom. He adds, that Volatile Salt thus purified may be kept a long time, and will retain all its whiteneſs.

If a Volatile Alkali thus purified be combined, to the point of ſaturation, with an Acid, ſuch as the Marine Acid for inſtance; the reſult of this union, as we ſhall afterwards ſee, will be a Sal Ammoniac, from which the Volatile Alkali may be ſeparated by the intervention of a Fixed Alkali. A Volatile Alkali that hath paſſed through all theſe trials will then be in the higheſt degree of purity that Chymiſtry can bring it to, and appears conſtantly the ſame, from whatever ſubſtance it was originally obtained: which proves that if Volatile Alkalis, extracted from different vegetable and animal ſubſtances, ſeem to differ from each other in ſome reſpects, this can ariſe only from the heterogeneous matters with which they are mixed; but that, at bottom, they are all conſtituted of one ſingle principle, which is conſtantly the ſame, and exactly alike in them all.

It is of the laſt conſequence, on all occaſions where a Volatile Alkali is to be diſtilled in a concrete form, to make uſe of ſubliming veſſels with very large necks, that it may have room enough to make its way to the receiver with eaſe; for otherwiſe it may choak up the paſſage, and burſt the veſſels.

PROCESS II.

Volatile Alkalis combined with Acids. Sundry Ammoniacal Salts. Sal Ammoniac.

ON a Volatile Spirit or Salt pour gradually any Acid whatever. An effervеſcence will ariſe, and be more or leſs violent according to the nature of the Acid. Go on adding more Acid in the ſame manner, till no effervеſcence be thereby excited, or at leaſt till it be very ſmall. The liquor will now contain a ſemi-volatile Neutral Salt, called an *Ammoniacal Salt;* which may be obtained in a dry form by cryſtallizing as uſual, or by ſubliming it in cloſe veſſels, after the ſuperfluous moiſture hath been drawn off.

OBSERVATIONS.

VOLATILE Alkalis have the ſame properties with Fixed Alkalis, fixity only excepted: ſo that a Volatile Alkali muſt produce an effervеſcence when mixed with Acids, and form therewith Neutral Salts, differing from each other in nothing but the nature of the Acid in their compoſition.

It muſt be obſerved, that, on this occaſion, the point of ſaturation is very difficult to hit; owing probably to the Volatility of the Alkali, which, being much lighter than the Acid, tends always to poſſeſs the uppermoſt part of the mixture, while the Acid ſinks to the bottom: whence it comes to paſs, that the lower part of the liquor is ſometimes overcharged with Acid, while the upper part is ſtill very Alkaline. But it is moſt eligible that the Alkali ſhould predominate in the mixture; becauſe the exceſs of this principle eaſily flies off, while the moiſture is evaporating, in order to the cryſtallization or ſublimation of the Ammoniacal Salt;

which being only ſemi-volatile reſiſts the heat longer, and remains perfectly Neutral.

If the Vitriolic Acid be combined with a Volatile Alkali, and the mixture diſtilled in a retort to draw off the ſuperfluous moiſture, a liquor comes over into the receiver, which ſmells ſtrong of a Sulphureous Acid. Now, as the Acid of Vitriol never becomes ſulphureous, but when it is combined with an inflammable matter, this experiment is one of thoſe which demonſtrate that Volatile Alkalis contain a very ſenſible quantity of inflammable matter. This ſame liquor taſtes of an Ammoniacal Salt; which proves that it carries up with it ſome of the Neutral Salt contained in the mixture. The reſt of this Salt, which is called *Glauber's Secret Sal Ammoniac*, or *Vitriolic Sal Ammoniac*, ſublimes into the neck of the retort. It is very pungent on the tongue; it crackles a little when thrown on a red hot ſhovel, and then flies off in vapours.

The Ammoniacal Salt formed by the Acid of Nitre exhibits much the ſame phenomena; but it requires greater care in drying and ſubliming it, becauſe it hath the property of detonating all alone, without the addition of any other inflammable matter: and it will infallibly do ſo, if too ſtrong a fire be applied towards the end of the operation, when it begins to be very dry. This property of detonating by itſelf it derives from the inflammable matter contained in the Volatile Alkali which ſerves for its baſis: and this is another demonſtrative proof of the exiſtence of ſuch an inflammable matter in the Volatile Alkali. This Salt is called *Nitrous Sal Ammoniac*.

With the vegetable Acids, that of Vinegar for inſtance, is formed an Ammoniacal Salt of a ſingular nature, and which can ſcarce be brought to a dry form.

A Volatile Alkali, combined to the point of ſaturation with the Acid of Sea-ſalt, forms another Neutral Salt, which takes a concrete form either by ſublimation or cryſtallization. The cryſtals of this Salt are ſo very ſoft and fine, that a parcel of it looks like cotton or wool. This is the Salt properly called *Sal Ammoniac*. It is of great uſe in Chymiſtry and in manufactures: but that which is daily conſumed in great quantities is not made in the manner above mentioned. It would come extremely dear if we had no other way of procuring it, but by forming it thus with the Acid of Sea-ſalt and a Volatile Alkali. This Salt, or at leaſt the materials of which it is formed, may be found in the fuliginoſities and ſoots of moſt animal, and of ſome vegetable ſubſtances.

The greateſt part of what we uſe comes from Egypt, where vaſt quantities thereof are made.

The method of preparing Sal Ammoniac in Egypt was not known among us, till Meſſ. Lemaire and Granger, two of the Academy's correſpondents, gave in ſeveral Memoirs in which that buſineſs is deſcribed with great accuracy, from their own view on the ſpot. Their Memoirs inform us, that chimney-ſoot alone, without any additament, is the matter from which they obtain their Sal Ammoniac; that thoſe chimneys under which nothing is burnt but Cow's-dung furniſh the beſt Soot. Six and twenty pounds of that Soot yield uſually ſix pounds of Sal Ammoniac.

" The operation takes up about fifty, or two and fifty " hours. The veſſels in which they put the ſoot are ballons " of very thin glaſs, terminating in a neck of fifteen or ſix- " teen lines long, and an inch in diameter: but they are not " all of the ſame ſize. The leaſt contain twelve pounds of " Soot, and the greateſt fifty; but they fill them only three " quarters full, in order to leave room for the ſublimation " of the Salt.

" The furnace, in which they place theſe ballons, conſiſts " of four walls, built in a quadrangular form. The two " front walls are ten, and the ſides nine feet long: but they " are all five feet high, and ten inches thick. Within the " quadrangle formed by theſe walls three arches run length- " wiſe from end to end thereof, at the diſtance of ten inches " aſunder. The mouth of this furnace is in the middle of one " of its fronts, and of an oval form; two feet four inches " high, and ſixteen inches wide.

" The ballons lie in the ſpaces between the arches of the " furnace, which ſerve inſtead of a grate to ſupport them. " Four of them are uſually placed in each interval; which " makes ſixteen for one furnace. They are ſet at the diſ- " tance of about half a foot from each other, and ſecured " in their places with brick and earth. But they leave about " four inches on the upper part of the ballon uncovered, " with a view to promote the ſublimation, as they alſo do " ſix inches of the inferior part, that the heat may the " better act on the matters to be ſublimed. Things being " thus prepared they firſt make a fire with ſtraw, which " they continue for an hour. Afterwards they throw in " Cow's-dung made up in ſquare cakes like bricks. (The " want of wood in this country is the reaſon that they generally " make uſe of this fuel). Theſe cakes of dung add to the " violence of the fire, which they continue in this manner

" for nineteen hours; after which they increaſe it conſider-
" ably for fifteen hours more; and then they ſlacken it by
" little and little.

" When the matter contained in the veſſels begins to
" grow hot, that is, after ſix or ſeven hours baking, it e-
" mits a very thick and ill-ſcented ſmoke, which continues
" for fifteen hours. Four hours after that, the Sal Ammo-
" niac is obſerved to riſe in white flowers, which adhere to
" the inſide of the neck of the veſſel; and thoſe who have
" the direction of the operation take care, from time to
" time, to paſs an iron rod into the neck of the ballon, in
" order to preſerve a paſſage through the ſaline vault, for
" giving vent to ſome blueiſh vapours, which conſtantly iſ-
" ſue out of the veſſel during the whole operation."

From this hiſtory of the preparation of Sal Ammoniac it appears that Soot, and particularly the Soot of animal matters, either contains abundance of this Salt perfectly formed, and waiting only for ſublimation to ſeparate it therefrom, or, at leaſt, that it contains the proper materials for forming it; and that during the operation, which is a kind of diſtillation of Soot, theſe materials combine together and ſublime.

We ſhewed, in our analyſis of Soot, that this ſubſtance yields by diſtillation a great deal of Volatile Alkali; and this is an ingredient which makes at leaſt one-half of Sal Ammoniac. As to the other principle of this Salt, I mean the Marine Acid, this alſo muſt needs exiſt in Soot: but it is not ſo eaſy to conceive how it ſhould come there.

It is very true that vegetable and animal ſubſtances, the only ones that produce Soot in burning, contain ſome portion of Sea-ſalt: but then this Salt is very fixed, and ſeems unfit to riſe with the Acid, the Oil, and the ſubtile Earth, of which the Volatile Alkali is formed. Therefore we muſt ſuppoſe either that its elevation is procured by the force of the fire, aided by the volatility of the matters that exhale in burning; or that, being decompoſed by the violence of the combuſtion, its Acid alone riſes with the other principles above-mentioned. The latter ſeems probable enough: for though in the common operations of Chymiſtry the bare force of fire doth not ſeem ſufficient to decompoſe Sea ſalt; yet the example of Sea-plants, which, before burning, contain this Salt in abundance, and whoſe aſhes contain ſcarce any at all, but are replete with its fixed part, that is, with its Alkaline baſis, ſeems to prove that, when this Salt is intimately mixed with inflammable matters, it may be deſtroyed by burning; ſo that its Acid ſhall deſert its baſis, and fly off with the Soot.

Before the exact method of procuring Sal Ammoniac was known, it was generally imagined that the manufacturers, mixed Sea-ſalt, and even Urine, with the Soot; becauſe theſe two ſubſtances contain the principles of which this Salt conſiſts. But, beſides that the contrary now certainly appears from the above-mentioned Memoirs, it hath been ſhewn by Mr. Duhamel, who hath publiſhed ſeveral Memoirs and experiments concerning the compoſition and decompoſition of Sal Ammoniac, from which we have partly taken what we have already ſaid on this ſubject, and which will furniſh us with ſome more curious obſervations; it hath been ſhewn, I ſay, in the firſt of Mr. Duhamel's Memoirs, printed with thoſe of the Academy for 1735, that the addition of Sea-ſalt to the Soot, from which Sal Ammoniac is to be extracted, contributes nothing to its production, and cannot increaſe its quantity. That alone, therefore, which was originally contained in the matters that produced the Soot, enters as a principle into the compoſition of Sal Ammoniac. We obſerved alſo, in treating of the analyſis of Soot, that Mr. Boerhaave obtained from it a conſiderable quantity of an Ammonical Salt without any additament.

Sal Ammoniac is ſometimes found perfectly formed in the neighbourhood of Volcanoes. This Salt is probably produced from the fuliginoſities of vegetable or animal matters conſumed by the fire of the Volcano.

Sal Ammoniac is often impure, becauſe it carries up with it, in ſublimation, ſome of the black charred matter which ought to be left at the bottom of the veſſel: but it is eaſily purified. For this purpoſe you need only diſſolve it in water, filter the ſolution, then evaporate and cryſtallize; by which means you will have a very white and very pure Sal Ammoniac. You may, if you pleaſe, ſublime it again in a cucurbit and blind head, with a fire not too briſk. Some of it will riſe in the form of a light white powder, called *Flowers of Sal Ammoniac*. Theſe Flowers are no other than true Sal Ammoniac, which hath ſuffered no decompoſition; becauſe the bare action of fire is not capable of ſeparating the Acid and the Volatile Alkali, of which this Neutral Salt conſiſts. When you intend to decompoſe it, you muſt uſe the means to be mentioned hereafter.

Though Sal Ammoniac be only ſemi-volatile, and requires a conſiderable heat to ſublime it, yet it hath the property of carrying up with it matters that are very fixed and ponderous;

ſuch as metallic ſubſtances, and ſome kinds of earths. For medicinal uſes we ſublime therewith Iron, Lapis Hæmatites, the Copper in blue Vitriol, &c. and then it takes different names, as *Martial Flowers of Sal Ammoniac*, *Ens veneris*, and other ſuch denominations, which it borrows from the matters ſublimed with it.

PROCESS III.

Sal Ammoniac decompounded by Acids.

INTO a large tubulated glaſs retort put a ſmall quantity of Sal Ammoniac in powder: ſet your retort in a furnace, and lute on a large ballon, as in the diſtillation of the ſmoaking Acids of Nitre and Sea-ſalt. Through the hole in your retort pour a quantity of Oil of Vitroil, or Spirit of Nitre, equal in weight to your Sal Ammoniac. An effervescence will inſtantly follow. The mixture will ſwell, and diſcharge white vapours, which will come over into the receiver. Stop the hole in the retort immediately, and let the firſt vapours paſs over, together with ſome drops of liquor, which will diſtil without fire. Then put a few coals into the furnace, and continue the diſtillation with a very gentle heat; which however muſt be increaſed, little by little, till nothing more will come off. When the operation is finiſhed, you will find in the receiver a Spirit of Salt, if you made uſe of Oil of Vitroil; or an *Aqua regis*, if Spirit of Nitre was employed: and in the retort will be left a ſaline maſs, which will be either a Glauber's Secret Sal Ammoniac, or a Nitrous Sal Ammoniac, according to the nature of the Acid uſed to decompound the Sal Ammoniac.

OBSERVATIONS.

SAL Ammoniac, which conſiſts of the Marine Acid united to a Volatile Alkali, is, with reſpect to the Vitriolic and Nitrous Acids, juſt the ſame as Sea-ſalt is with reſpect to thoſe Acids; that is, the Vitriolic and Nitrous Acids, having a greater affinity, than the Marine Acid, with Volatile as well as Fixed Alkalis, will decompound the Sal Ammoniac, by expelling the Acid from its baſis, and aſſuming its place, juſt as they do with regard to Sea-ſalt. Moſt therefore of what was ſaid concerning the decompoſition of Sea-ſalt, and the diſtillation of its Acid, by the two other Acids, muſt be applied here.

We ſhall only obſerve, that, when the Acid of Sal Ammoniac is to be diſtilled from it by the interpoſition of the Vitriolic or Nitrous Acid, great care muſt be taken to put but a very ſmall quantity of this Salt into the retort; eſpecially if the Acids to be added are concentrated: for, as ſoon as they mix with the Sal Ammoniac, a great effervefcence ariſes, and the mixture ſwells to ſuch a degree, that, unleſs the quantity in the retort be very ſmall, it may run over altogether into the receiver. It is alſo proper to take notice, that this operation admits of but a ſmall degree of heat, for two reaſons; firſt, becauſe the Acid of the Sal Ammoniac, being very eaſily diſlodged by an Acid ſtronger than itſelf, riſes alſo very eaſily; ſecondly, becauſe the Sal Ammoniac which is to be decompounded, as well as the Ammoniacal Salts which reſult from its decompoſition, are ſemi-volatile, and will ſublime in ſubſtance if they be expoſed to the ſmalleſt exceſs of heat. Moreover, the Nitrous Sal Ammoniac would be in danger of taking fire and exploding, for a reaſon frequently mentioned above.

The Nitrous Sal Ammoniac may be decompounded, as well as Sal Ammoniac, by the Vitriolic Acid. But, as the Nitrous Acid contained in the Salt is the ſtrongeſt of all Acids next to the Vitriolic, no other Acid but this is able to expel it from its baſis; in which reſpect this Salt reſembles Nitre.

Inſtead of employing the Acids of Vitriol and Nitre to decompound Sal Ammoniac, we might make uſe of Neutral Salts conſiſting of theſe Acids combined with metallic or earthy baſes: but then, as this decompoſition cannot be effected without a greater degree of heat, there is reaſon to apprehend that ſome of the Sal Ammoniac would be thereby ſublimed, before it could be decompounded.

PROCESS IV.

Sal Ammoniac decompounded by Fixed Alkalis. Volatile Salt. The Febrifuge of Sylvius

INTO a glaſs alembic or retort put Sal Ammoniac and Salt of Tartar, pulverized and mixed together in equal quantities. Set your veſſel in a proper furnace, and immediately lute on a large receiver. A little volatile Spirit will aſcend; and a volatile Alkali, in a concrete form, very white and beautiful, will ſublime into the head, and come over into the receiver, in quantity near two thirds or three fourths of the Sal Ammoniac uſed. Continue the diſtillation, increaſing the fire by degrees, till nothing more will ſublime. Then unlute the veſſels. Put up your Volatile Salt immediately into a wide-mouthed bottle, and ſtop it cloſe with a cryſtal ſtopple. At the bottom of the retort, or cucurbit, you will find a ſaline maſs, which, being diſſolved and cryſtallized, will form a Salt nearly cubical, having the taſte and other properties of Sea-ſalt. This is the *Sal Febrifugum Sylvii.*

OBSERVATIONS.

THIS decompoſition of Sal Ammoniac is the reverſe of that in the preceding proceſs. In the former operation it was ſhewn that the Acid of Sal Ammoniac may be ſeparated from its baſis, by applying to that baſis a ſtronger Acid: in the preſent operation, on the contrary, the baſis of this Salt is ſeparated from its Acid, by preſenting to that Acid a Fixed Alkali, wherewith it hath a greater affinity than with the Volatile Alkali which ſerves it for a baſis.

The action of Fixed Alkalis upon Sal Ammoniac is ſo vigorous and ſudden, that, as ſoon as theſe two matters are mixed together, the Volatile urinous Salt ruſhes out with great activity, even without the help of heat; ſo that much of it will be loſt, if care be not taken to confine the mixture immediately in thoſe veſſels by means of which it is to be diſtilled

The Volatile Salt obtained by this operation is white, pure, and very active; having been freed from the greateſt part of its ſuperfluous fat matter, both by the union it had contracted with the Marine Acid, and by the Fixed Alkali employed to ſeparate it therefrom. This Salt is ſo quick and volatile, that if, on taking out the receiver, it be left a little too long expoſed to the air, before it be put into the bottle in which it is to be kept, a great deal of it will exhale and be loſt. For the ſame reaſon care ſhould be taken, while the veſſels are unluting, that the vapour of this Salt do not ſtrike the organ of ſmelling, or be drawn into the lungs in reſpiration; for it affects thoſe organs ſo powerfully, and makes ſuch a quick impreſſion on them, that the operator would be in danger of ſuffocation. Yet it is of great ſervice, when cautiouſly ſmelled to, for exciting the vibrations of the *Genus Nervoſum*, in Apoplexies, Fainting fits, and Hyſterical diſorders. But it muſt always be adminiſtered with great caution; for it hath a corroſive quality, and is no leſs cauſtic than a Fixed Alkali. This is proved by applying it to the bare ſkin, and keeping it on by means of a pitch-plaſter, ſo that it cannot fly off in vapours: for, as ſoon as it begins to grow warm, it produces on the ſkin a ſmarting ſenſation, like that of burning, attended with much pain, and in a very ſhort time makes an eſchar like a cauſtic.

The Volatile Spirit, obtained in the decompoſition of Sal Ammoniac by a Fixed Alkali, derives its origin from the Phlegm contained in the ſaline matters that are mixed together on that occaſion. The moiſter thoſe matters are, the more Spirit there will be. This alſo is very active and penetrating. But as it owes theſe qualities wholly to the Volatile Salt diſſolved in it, the more of this Spirit comes off, the leſs Salt will there be.

If you deſire to have much Volatile Spirit, a quantity of water, proportioned to the quantity of Spirit you want, muſt be mixed with the Salts. In this caſe the diſtillation begins with a humid vapour, which coagulates on the ſides of the receiver into a concrete Salt, almoſt as ſoon as it comes over. There riſes afterwards an aqueous vapour, not ſo ſaline or volatile as the former. This liquor diſſolves the Salt that was coagulated before; and, if the water added was in ſufficient quantity, it will diſſolve the Salt entirely; otherwiſe it will diſſolve but a part thereof, and then it is certain that the liquor is a Volatile Spirit as ſtrongly impregnated with Salt as it can be. The reaſon why the liquor that riſes firſt contains a great deal more Volatile Salt than the other, in ſo much that it coagulates and becomes ſolid, is becauſe the Volatile Salt riſes in diſtillation much more eaſily than water.

In whatever manner the Volatile Spirit or Salt be diſtilled from Sal Ammoniac, by means of a Fixed Alkali, we always find at the bottom of the retort, or cucurbit, when the operation is finiſhed, a new Neutral Salt compounded of the Acid of the Sal Ammoniac, and of the Alkali uſed in the diſtillation. If the Salt of Tartar be uſed, this new Neutral Salt will be perfectly like that produced by combining this Alkali with the Acid of Sea-ſalt, to the point of ſaturation. The figure of the cryſtals of this Salt, though much like that of the cryſtals of Sea-ſalt, is nevertheleſs a little different. However, this Salt poſſeſſes the chief properties of Sea-ſalt. It bears the name of *Sal Febrifugum Sylvii*, becauſe that Phyſician attributed to it the virtue of curing intermitting fevers. But its title to this virtue is very doubtful, at leaſt in this country.

If the Salt of Soda be uſed, inſtead of Salt of Tartar, to decompound Sal Ammoniac, a Volatile Spirit and Salt will in like manner be obtained; and the Neutral Salt left in the retort, after diſtillation, will be a true regenerated Sea-ſalt, perfectly like native Sea-ſalt; becauſe, as we have ſaid before, the Salt of Soda is of the ſame kind with the natural baſis of Sea-ſalt; and the inconſiderable differences, obſervable between the *Sal Febrifugum* and Sea-ſalt, can be attributed only to ſuch as may be found between the Alkaline baſes of thoſe two Salts.

PROCESS V.

Sal Ammoniac decompounded by Abſorbent Earths and Lime. The Volatile Spirit of Sal Ammoniac. Fixed Sal Ammoniac. Oil of Lime.

LET one part of Sal Ammoniac, and three parts of Lime, ſlaked in the air, be pulverized ſeparately, and expeditiouſly mixed together. Put this mixture immediately into a glaſs retort, ſo large that half of it may remain empty. Apply thereto a capacious receiver, with a ſmall hole in it to give vent to the vapours, if needful. Let your retort ſtand in the furnace about a quarter of an hour, without any fire under it. While it ſtands thus, a great quantity of inviſible vapours will riſe, condenſe into drops, and form a liquor in the receiver. Then put two or three live coals in your furnace, and gradually increaſe the fire till no more liquor will riſe. Now unlute your veſſels, taking all poſſible care to avoid the vapours, and quickly pour the liquor out of the receiver into a bottle, which you muſt ſtop with a cryſtal ſtopple rubbed with emery. There will remain, at the bottom of the retort, a white maſs, conſiſting of the Lime employed in the diſtillation, together with the Acid of the Sal Ammoniac: this is called *Fixed Sal Ammoniac.*

OBSERVATIONS.

In our Elements of the Theory, we explained how we imagine that Lime and other ſubſtances, which, according to the Table, have leſs affinity than Volatile Alkalis with Acids, are nevertheleſs capable of decompounding Sal Ammoniac, by uniting with its Acid, after expelling it from its baſis, which is a Volatile Alkali. To recapitulate our opinion in two words: we conceive this to depend on the fixedneſs of theſe earthy and metallic additaments, which enables them to reſiſt the force of fire, and on the volatility of the baſis of Sal Ammoniac, which proves a great diſadvantage to it when it comes to ſtruggle, as it were, with thoſe fixed additaments, aided by a conſiderable degree of heat. We ſhall only obſerve, that we are not ſingular in this opinion, nor indeed did we deliver it as a new one; that ſeveral modern Chymiſts concur with us therein, and particularly Mr. Baron, whom we have already mentioned more than once on the ſubject of Borax; and who, we think, was the firſt that ever took particular notice of it in print, viz. in his Memoirs on Borax, communicated to the Academy before the publication of our Elements. For the explanation of this phenomenon, therefore, we refer to thoſe Memoirs, which are actually publiſhed, and to what we have already ſaid on the ſubject in our treatiſe above-mentioned.

Another phenomenon, which is equally ſingular and curious, furniſhes us with matter for ſeveral reflections, and gives us occaſion to relate, in few words, the reſult of Mr. Duhamel's moſt ſagacious experiments and ſpeculations tending to diſcover the cauſe thereof. The point under conſideration is the different forms and properties which the Volatile Alkali aſſumes, when ſeparated from Sal Ammoniac by the means of a Fixed Alkali, and by the means of Lime. We know that the former is always in a concrete form, unleſs the mixture, from which it is diſtilled, be abſolutely drenched with water; and that the latter, on the contrary, is always in a fluid form, and conſtantly liquid, whatever method be taken to diſtil it.

Some Chymiſts imagine, that the Volatile Salt of Sal Ammoniac appears in a concrete form, only becauſe it ſtill contains ſome Acid; whence they conclude that the reaſon why no concrete Volatile Salt can be obtained by the means of Lime is, becauſe it abſorbs all the Acid of the Sal Ammoniac; which is not the caſe, they ſay, with Fixed Alkalis. Others impute the conſtant fluidity of the Volatile Spirit of Sal Ammoniac, obtained with Lime, to the particles of fire which they ſuppoſe communicated thereto by that ſubſtance. Mr. Duhamel equally refutes both theſe opinions, by proving from experiments that Fixed Alkalis are capable of abſorbing as much Acid as Lime can, and even more; and that, having been calcined as long, and with as violent a fire, as Lime, they muſt contain and communicate as many particles of fire; if indeed it be poſſible that the particles of fire ſhould actually be lodged, and continue impriſoned, in calcined ſubſtances, as theſe gentlemen ſuppoſe. Yet this is contrary to experience; ſeeing the Volatile Salt diſtilled by the means of a Fixed Alkali, though ever ſo long and ever ſo violently calcined, is always in a concrete form, and doth not reſemble the Volatile Spirit of Sal Ammoniac prepared with Lime.

In order to throw the neceſſary lights on this point, Mr. Duhamel had recourſe to the only method that can be depended on in Natural Philoſophy; namely, Experiments. He accordingly made ſeveral, of which theſe are the chief.

Firſt, he diſtilled a Volatile Salt, by the means of well deſiccated Salt of Tartar, and Salt of Soda; and, urging the fire with great violence towards the end of the operation, he thus obtained a quantity of Volatile Salt equal to, or even exceeding, that of the Sal Ammoniac he uſed: whence he juſtly concluded that, on this occaſion, the Volatile Salt carried up, and volatilized ſome of the Fixed Salt.

Secondly, he found upon trial that the Volatile Spirit, obtained from Sal Ammoniac by the means of Lime, appears in the form of a liquor, only becauſe it is mixed with ſome water which was contained in the Lime. Of this truth he had the following deciſive proof: having attempted to prepare a Volatile Spirit of Sal Ammoniac with Lime, which had not been ſlaked, either in the air or by water, he could not obtain any Volatile Spirit: or, at leaſt, the quantity was ſo ſmall that it might be reckoned as nothing; and even that was wholly due to the moiſture which Sal Ammoniac neceſſarily contains, together with that which Lime imbibes from the air, if ever ſo little expoſed thereto.

From theſe two experiments Mr. Duhamel draws the following conſequences: viz. that the Volatile Salt cannot be ſeparated from the Sal Ammoniac and ſublimed, without carrying along with it ſome of the additament which ſerves to extricate it; or, inſtead thereof, ſome other body with which it is capable of uniting: that Fixed Alkalis have the property of being thus carried up by the Volatile Alkali, and ſubliming with it: that the caſe is not the ſame with Lime, which therefore cannot, when alone, ſeparate and ſublime the Volatile Alkali of the Sal Ammoniac; but becomes capable thereof when it hath imbibed any moiſture, which joins with the Volatile Salt, and riſes therewith in diſtillation. And hence it muſt be concluded, that, ſeeing the Volatile Salt carries up with it ſome of the Fixed Alkali, by the means of which it is ſeparated, it will be in a concrete form; what it carries up along with it being dry and ſolid: whereas, when it is diſtilled with Lime, it cannot but be liquid; ſeeing it muſt needs be diſſolved by the moiſture it gets from the Lime, without which it would not riſe.

But to what muſt we attribute theſe effects produced by Lime, ſo different from thoſe produced by Fixed Alkalis? Are they owing to its quality of Lime? or would it produce the ſame, if it were only a mere Abſorbent Earth? Mr. Duhamel hath anſwered this queſtion by a third ſort of experiment. He tried to decompound Sal Ammoniac, and to ſeparate its Volatile Alkali, by a pure Abſorbent of Earth, without mixing any water with it, or calcining it.

For this purpoſe he made uſe of Chalk; and his experiment ſucceeded. By means of this additament he decompounded Sal Ammoniac, and by the experiment obtained the lights he wanted. The Volatile Alkali, being extricated by the dry but uncalcined Chalk, roſe in a concrete form, as with Fixed Alkalis; and in like manner carried up with it ſome of the earthy additament. The ſame Chalk when calcined, and converted into Lime, produced the very effect of Lime on Sal Ammoniac. It is therefore from calcination alone that Abſorbent Earths derive the property of retaining obſtinately the Volatile Alkali, and preventing its ſublimation by refuſing to riſe with it as Fixed Alkalis do.

Though theſe ingenious experiments evidently furniſh us with great lights, for diſcovering the cauſe of the ſolidity or fluidity of the Volatile Alkali, when ſeparated from Sal Ammoniac by different additaments, as they fully determine ſeveral preliminary queſtions immediately relating thereto; yet they ſtill leave us, in ſome meaſure, at a loſs with regard to the chief point. For we do not yet know why Fixed Alkalis and Abſorbent Earths, which, in all Chymical trials, ſhew that they have certainly as much fixity as Lime, are carried up by the Volatile Alkali, while Lime reſiſts, inſtead of riſing with it as thoſe other ſubſtances do, obſtinately retains it, and even fixes it in ſome meaſure, ſo that it is impoſſible

poſſible for it to ſublime. This queſtion, in my opinion, depends on the theory of Lime; nor can we hope to reſolve it in its full extent, till we get a further inſight into the nature of that ſingular ſubſtance than we have at preſent.

On this ſubject, however, Mr. Duhamel hath offered ſome conjectures, founded on the known properties of Lime, and ſupported by experiments. "Lime," ſays he, "is an "earth freed by calcination from almoſt all its humidity, "almoſt all its Acid, and all the fat it contained; whether "that fat came from ſome animal parts, as is the caſe of "thoſe ſtones which conſiſt of ſhells; or whether it were a "bituminous fat, as may happen to be the caſe with ſome "others: this ſubſtance is withal acrid and fiery; it is very "greedy of moiſture, and imbibes it when expoſed thereto. "It abſorbs Acids, and retains them ſtrongly; and, laſtly, "it unites with fat matters, and therewith makes a kind of "ſoap."

All theſe properties are verified by experiments; and therefore Mr. Duhamel thinks he hath a right to ſay, that Lime acts not only on the Acid of Sal Ammoniac, but alſo on the fatty matter which always accompanies Volatile Alkalis, and is eſſential to their nature; and therefore it decompounds them. Of this Mr Duhamel gives the following convincing proof, founded on experiment. He took ſome Volatile Spirit diſtilled with Lime, and abſtracted it ſeveral times from a freſh parcel of Quick-Lime. The quantity of the Spirit diminiſhed ſenſibly every time; and the Lime was at laſt ſo replete with fat, that the Vitriolic Acid, when poured thereon, became very ſulphureous; and moreover, when calcined in a crucible, it emitted a very perceptible ſmell of burnt greaſe.

Indeed Fixed Alkalis are alſo capable of abſorbing and retaining fat matters; but not near ſo ſtrongly as Lime: becauſe theſe Salts are never entirely freed from that which they contain originally; whereas Lime ſeems much poorer, and abſolutely void of any oily matter.

On theſe principles Mr. Duhamel reſolved to try if he could not obtain a Volatile Alkali in a concrete form, by diſtilling the Volatile Spirit from Lime, brought nearly to the condition of a Fixed Alkali, by imbibing a portion of fat matter. With this view he diſtilled a great quantity of Volatile Spirit from a little Lime, and actually obtained a ſmall portion of Volatile Salt; becauſe the great quantity of Volatile Spirit had, in ſome meaſure, ſaturated the Lime with fat matter.

Mr. Duhamel tried alſo to bring Lime back to the condition of a pure Abſorbent Earth, to *decalcine* it, if I may uſe the term; in order to try whether he could not by this means make it produce the ſame effect as Chalk. For this purpoſe he lixiviated ſome Lime four months ſucceſſively, pouring every day freſh water on it, and removing that of the preceding day, together with the cryſtalline cruſt which always formed on it; and after leaving this Lime two years in the ſhade, he applied it to Sal Ammoniac. It produced a moderate quantity of Volatile Salt, which was very tranſparent. and ſeemed to be cryſtallized in cubes. Thus we ſee Lime rendered very like Chalk. Yet it was pretty acrid on the tongue, and the Volatile Salt, obtained by its means, was more diſpoſed to run into a liquid than that ſeparated by Chalk: which ſhews that this Lime ſtill retained ſome part of its former character, and that its transformation was not complete.

To conclude what relates to the Volatile Alkali of Sal Ammoniac, it only remains that we ſay a word or two of that portion of the earthy or ſaline additament, which, though fixed in its nature, ſublimes nevertheleſs with the Volatile Alkali, and gives it a concrete form.

Mr. Duhamel, who, in every ſubject that he handles, omits nothing worthy of attention, made ſeveral other experiments, with a view to diſcover whether or no the Salt of Tartar, and the Chalk, carried up by the Volatile Alkali, be truly volatilized; and whether or no there be ſuch a ſtrict union contracted, between the Urinous Salt and theſe fixed ſubſtances, that the whole reſults in what is called a *Concrete Volatile Salt;* or if thoſe fixed ſubſtances be united but ſuperficially with the Urinous Salt, which only carries them up along with itſelf in ſublimation, as Sal Ammoniac carries up ſeveral very fixed metallic matters.

The reſult of the experiments made by Mr. Duhamel for this purpoſe is, that the fixed ſubſtances carried up by the Volatile Alkali of the Sal Ammoniac are actually volatilized; that they make, as it were, one whole with it; and are ſo cloſely combined therewith, that almoſt all the moſt efficacious means of ſeparating fixed from volatile matters are unſucceſsful with regard thereto. Nothing, for inſtance, is fitter to ſeparate a volatile ſubſtance from a fixed one, than to mix the compound with a great quantity of water, and to diſtil the whole, with ſuch a degree of heat as ſhall be exactly ſufficient to elevate the volatile part. In this manner Mr. Duhamel treated Volatile Alkalis replete with Fixed

Salt, and with Chalk: but though he applied no more than the gentleſt degree of heat; nay, expoſed his mixture to the air only, fearing leſt he ſhould make the heat too ſtrong if he uſed fire; yet the fixed part, which the Volatile Salt had carried up with it, continued ſtill united therewith; ſo that the whole paſſed over in diſtillation, or was diſſipated by evaporation, without leaving any thing fixed at the bottom of the veſſel.

He alſo juſtly looked on Acids as an effectual means of procuring the ſeparation, or decompoſition, he was in queſt of. We know that, with the Volatile Alkali, they form Ammoniacal Salts, which, though they are not ſo light as the Volatile Alkali, ſublime nevertheleſs with a moderate heat; and that, on the contrary, the ſame Acids with Fixed Alkalis, or Abſorbent Earths, form Neutral Salts, which reſiſt the violence of fire. On this principle Mr. Duhamel poured Acids, to the point of ſaturation, upon Volatile Alkalis containing much Fixed Alkali, or Chalk. But this experiment ſucceeded no better than the foregoing; for the mixture being put to diſtil, ſublimed wholly in Sal Ammoniac. Indeed a little fixed matter was left at the bottom of the retort; but the quantity thereof was too ſmall to merit notice.

At laſt, the only way Mr. Duhamel could think of, for ſeparating, from a Concrete Volatile Alkali, the fixed parts which that Salt had rendered Volatile, was to expoſe it to the air, covered with a piece of gauze only; but in its dry ſtate, without diſſolving it in water. The Volatile Urinous Salt was by this means diſſipated; having deſerted the fixed part, which remained at the bottom of the baſon, and, being expoſed to the fire, retained its fixed nature. But it took more than a year to effect this ſeparation; nor are we ſure that it was complete; for it is not certain that all the fixed part was left behind, and that ſome of it was not diſſipated with the Volatile Urinous Salt.

This volatilization, this kind of metamorphoſis of a Fixed Alkali and an Abſorbent Earth into a Volatile Alkali, is a very curious phenomenon, and deſerves to be conſidered by the beſt Chymiſts.

We ſhall finiſh our obſervations on the decompoſition of Sal Ammoniac by Lime, with ſome reflections on the nature of the *caput mortuum* that remains after this diſtillation.

This reſiduum is only Lime impregnated, but not ſaturated, with the Acid of Sea-ſalt. If the diſtillation be urged at laſt with a violent fire, the *caput mortuum* will be found formed into a maſs, ſeeming to have been half-melted. This matter is a kind of Phoſphorus, and emits light in the dark, when ſtruck with any hard body. Mr. Homberg was the firſt who diſcovered it to have this property. Having calcined, and melted together in a crucible, one part of Sal Ammoniac and two parts of Lime, with a deſign to fix that Salt, he obſerved the maſs remaining after the fuſion to have the property juſt mentioned.

Lime, thus impregnated with the Acid of Sal Ammoniac, is very improperly called by the name of *Fixed Sal Ammoniac*. This compound attracts the moiſture of the air, and even runs wholly into a liquid, if it be impregnated with much Acid. It hath almoſt all the properties of Fixed Alkalis. This liquid is called *Oil of Lime*, for the ſame reaſon that deliquated Salt of Tartar is called *Oil* of *Tartar*.

PROCESS VI.

Volatile Alkalis combined with Oily matters. A Volatile Oily Aromatic Salt.

PULVERISE and mix together equal parts of Sal Ammoniac and Salt of Tartar: put the mixture into a glaſs or ſtone cucurbit: pour on it good Spirit of Wine, till it riſe half an inch above the matter. Mix the whole with a wooden ſpatula; apply a head and a receiver, and diſtil in a ſand-bath, gently heated, for two or three hours A Volatile Salt will riſe into the head; and then the Spirit of Wine will diſtil into the receiver, carrying with it a portion of the Volatile Salt.

When nothing more will come over, let your veſſels cool; then unlute them, ſeparate the Volatile Salt, and weigh it directly. Return it into a glaſs cucurbit, and for every ounce thereof add a dram and a half of Eſſential Oil, drawn from one or more ſorts of aromatic plants. Stir the whole with a wooden ſpatula, that the Eſſence may incorporate thoroughly with the Volatile Salt. Cover the cucurbit with a head, fit on a receiver, and, having luted it exactly, diſtil in a ſand-bath, as before, with a very gentle heat. All the Volatile Salt will riſe, and ſtick to the head. Let the fire go out, and when the veſſels are cooled take your Salt out of the head. It will have an odour compounded of its own proper ſmell, and the ſmell of the Eſſence with which it is combined. This is an *Aromatic Oily Salt.* Put it into a bottle ſtopped cloſe with a cryſtal ſtopple.

OBSERVATIONS.

THE deſign of this operation is to incorporate and unite an Oil with a Volatile Alkali. Spirit of Wine is added in the diſtillation of the Volatile Salt, intended for this purpoſe, in order to prepare it for receiving the Oil, and combining more eaſily therewith. This Salt hath the property, as was ſhewn in the preceding operation, to carry up with it part of the ſubſtances with which it is diſtilled On this occaſion therefore, it is impregnated with a little of the Spirit of Wine; and this Spirit, which contains in itſelf an oily matter, and is the ſolvent of Oils, cannot fail to facilitate the union of the Oil with the Volatile Salt, as it ſerves for a medium between them. Yet it muſt not be conſidered as a neceſſary one. A Volatile Salt, ſublimed with Salt of Tartar alone, would alſo very readily take up any Oil with which it ſhould be diſtilled. We have ſeen that Volatile Alkalis are originally impregnated with much Oil, which is radically diſſolved in them; and conſequently they have a great affinity with that ſubſtance. So that if we diſtil them with Spirit of Wine, at the beginning of this operation, we do it not out of any neceſſity, but only with a view to accelerate or facilitate the intended union.

In this diſtillation the Volatile Alkali always riſes firſt, and before the Spirit of Wine; which proves that it is much more volatile, though it be more ponderous than the Spirit.

If the Spirit of Wine uſed in this diſtillation be very aqueous, it will diſſolve the Salt as it comes over, and will reduce it into a Spirit: but if, on the contrary, it be well dephlegmated, the Volatile Alkali will remain in a concrete form, and will not be diſſolved in this firſt diſtillation.

If you deſire to have the Volatile Salt entirely diſſolved in the Spirit of Wine, though highly dephlegmated, it muſt be repeatedly diſtilled a great number of times with the ſame Spirit of Wine: for, though the ſmall quantity of Spirit of Wine, with which it unites in the firſt diſtillation, be not capable of reducing it into a liquid, yet, as it takes up more and more every time it is diſtilled, it diſſolves at laſt, and then with the Spirit of Wine forms a fluid that appears perfectly homogeneous. The Volatile Alkali is now rendered conſiderably milder by the union thus contracted, and is accordingly called the *Dulcified Volatile Spirit of Sal Ammoniac.*

When well dephlegmated Spirit of Wine is mixed with a Volatile Spirit of Sal Ammoniac, perfectly ſaturated with Volatile Salt, theſe two liquors together immediately form a white opaque *coagulum.* But for this purpoſe you muſt not uſe a Volatile Spirit diſtilled with Lime; for then the experiment will not ſucceed.

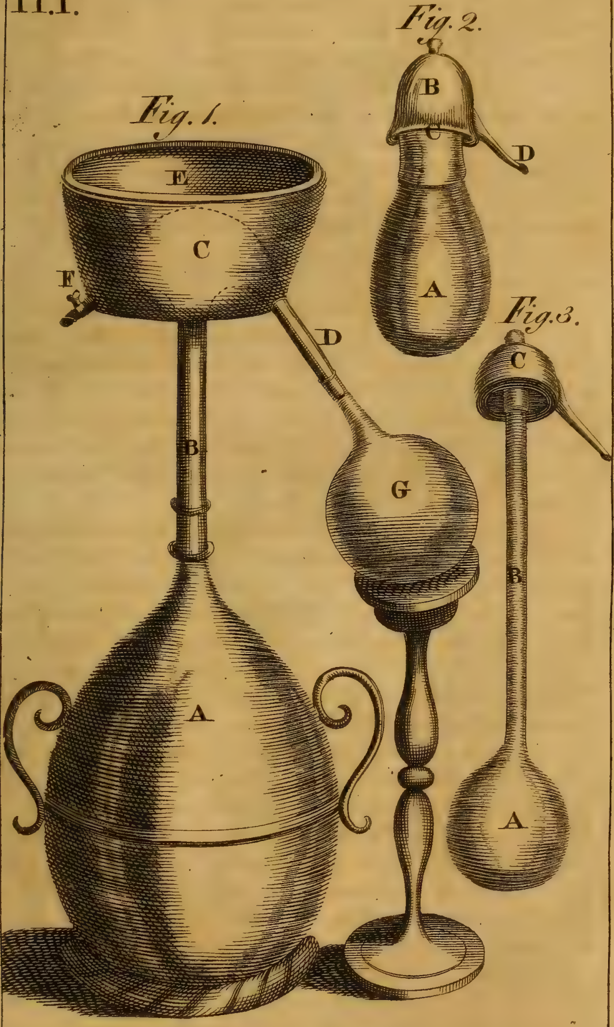
This *coagulum* does not ſeem to be the effect of an intimate union between the two ſubſtances mixed together, like that which reſults from the union of a Fixed Alkali with an Oil. It hath juſt now been ſhewn that Spirit of Wine and a Volatile Alkali do not readily unite together. I believe the effect rather depends on this, that Spirit of Wine hath a greater affinity than the Volatile Salt with water; and therefore the Spirit, which ought to be perfectly dephlegmated, attracts the water wherein the Volatile Salt was diſſolved, which thereupon recovers its concrete form; and being at that time mixed with the Spirit of Wine, it keeps that Spirit locked up among its parts, and hinders it from appearing with its natural fluidity.

What confirms this notion is, that the *coagulum*, which at firſt ſeems to make but one whole, ſoon ſeparates into two parts, whereof one, which is ſolid, and nothing but the Volatile Salt concreted, lies at the bottom of the veſſel; and the other, which is fluid, cannot be miſtaken for any thing but the Spirit of Wine, which, being diſengaged from the particles of Salt, recovers the form of a liquid, and, being the lighteſt, floats over the Salt. Yet theſe two ſubſtances, though now very diſtinct from each other, are not ſo pure as before they were mixed together. The Spirit of Wine hath diſſolved a little of the Volatile Salt; and, on the other hand, the Volatile Salt retains a little of the Spirit of Wine. They may indeed be perfectly united and blended with each other, by the method above delivered; that is, by being frequently diſtilled and cohobated together, till they form one mixt; but then that mixt will be in a liquid form.

The firſt time this mixture is diſtilled, a great deal of Volatile Salt riſes firſt, which is very fit to unite with an Eſſential Oil, and ſo to become a Volatile Oily Aromatic Salt.

THE END.

Pl.I.



Pl. II.

Fig. 1.

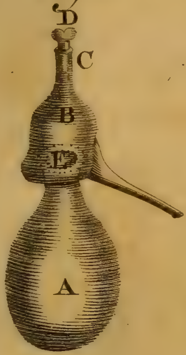


Fig. 2.

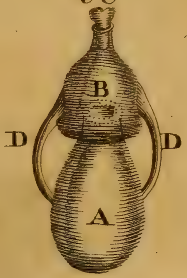
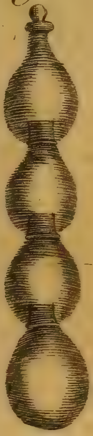


Fig. 3.



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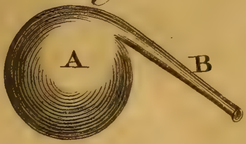
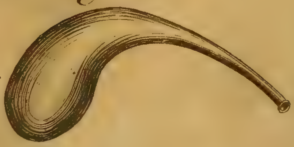


Fig. 5.



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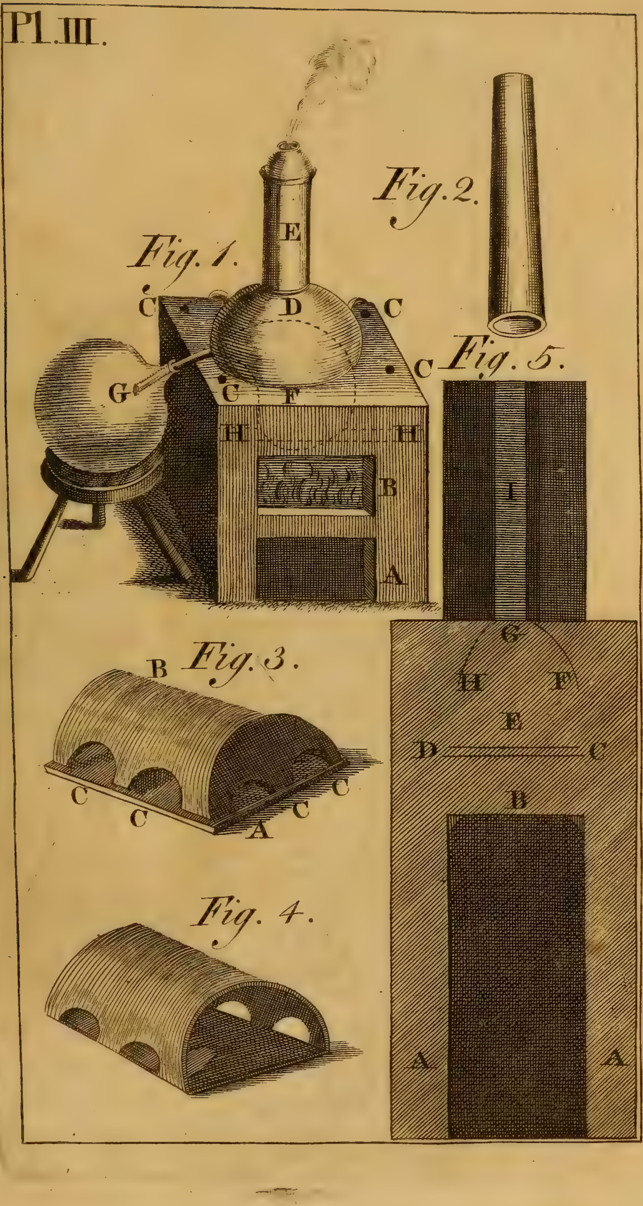
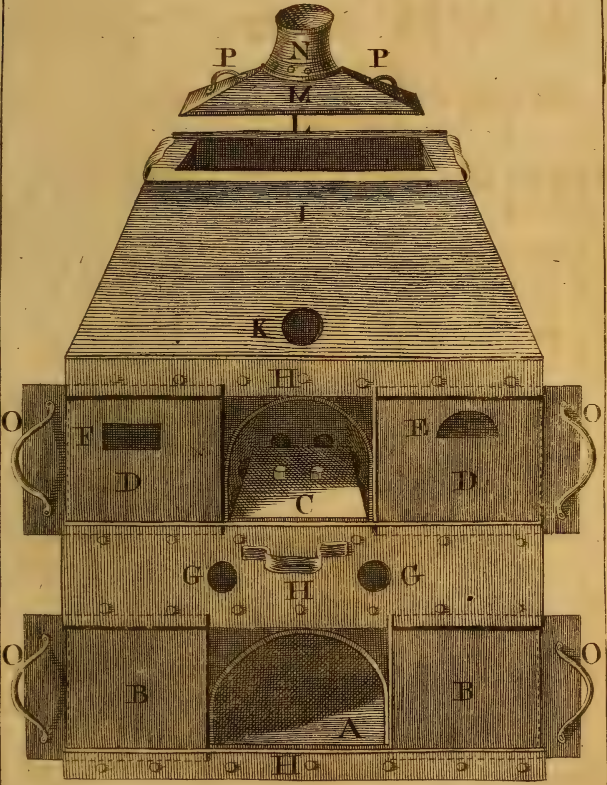


Pl. IV.



Pl.V.

GEOFFROY'S TABLE of the
observed between

I.	II.	III.	IV.	V.	VI.	VII.	VIII.
⌢	>⊖	>⦶	>⊕	▽	⊖v	⊖^	MS
⊖v	♃	♂	🜍	>⊕	>⊕	>⊕	>⊖
⊖^	♕	♀	⊖v	>⦶	>⦶	>⦶	>⊕
▽	♀	♄	⊖^	>⊖	>⊖	>⊖	>⦶
MS	☽	☿	▽		✢		✢
	☿	☽	♂		🜍		
			♀				
			☽				
	☉						

Explanation of

⌢ *Acid Spirits*
>⊖ *Marine Acid*
>⦶ *Nitrous Acid*
>⊕ *Vitriolic Acid*
⊖v *Fixed Alkali*
⊖^ *Volatile Alkali*

▽ *Absorvent Earths*
MS *Metallic Substances*
☿ *Mercury*
♕ *Regulus of Antimony*
☉ *Gold*
☽ *Silver*

Pl.VI. *COMPARATIVE AFFINITIES*
ſundry Subſtances.

IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
🜍	☿	♄	♀	☽	♂	🜲	🜄
⊖v	☉	☽	☿	♄	🜲	♂	🜄ˢ
♂	☽	♀	LC	♀	☽ ♄ ♀	☽ ♄ ♀	⊖
♀	♄						
♄	♀						
☽	Ze						
🜲	🜲						
☿							
☉							

the Characters

♀ *Copper*	🜍 *Sulphur*
♂ *Iron*	🜍 *Phlogiſton*
♄ *Lead*	🜊 *ſpirit of Vinegar*
♃ *Tin*	🜄 *Water*
Ze *Zinc*	⊖ *Neutral Salts*
LC *Calamine*	🜄ˢ *Ardent Spirits*

EXPLANATION OF THE PLATES.

PLATE FIRST.

FIG. I. *A Copper Alembic.*

A. The Cucurbit or Body.
B. The Neck.
C. The Head.
D. The Beak, Noſe, or Spout.
E. The Refrigeratory, or Cooler.
F. Its Cock.
G. The Receiver.

FIG. II. *A Glaſs Alembic.*

A. The Cucurbit.
B. The Head.
C. The Gutter within the Head.
D. The Beak.

FIG. III. *A long-necked Glaſs Alembic.*

A. The Body of the Matraſs.
B. The Neck.
C. The Head.

PLATE SECOND.

FIG. I. *A Glaſs Alembic of one piece.*

A. The Cucurbit.
B. The Head.
C. The Aperture in the Head.
D. Its Stopple.
E. The Mouth of the Cucurbit.

FIG. II. *A Pelican.*

A. The Cucurbit.
B. The Head.
C. The Aperture in the Head, with its Stopple.
D. D. The two curved Spouts.

FIG. III. *A Row of Aludels.*

FIG. IV. *A Retort.*

A. Its Bowl.
B. Its Neck.

FIG. V. *An Engliſh Retort.*

PLATE THIRD.

FIG. I. *A Reverberating Furnace.*

A. The Aſh-hole Door.
B. The Fire-place Door.
C. C. C. C. Regiſters.

D. The Dome, or Reverberatory.
E. The Conical Funnel.
F. The Retort in the Furnace.
G. The Receiver.
H. H. Iron Bars to ſuſtain the Retort.

FIG. II. *The Conical Funnel by itſelf.*

FIG. III. *Back View of a Muffle.*

A. The bottom of the Muffle.
B. Its Arch.
C. C. C. Lateral apertures.

FIG. IV. *Fore-View of a Muffle.*

FIG. V. *A Melting Furnace.*

A. A. The Baſe of the Furnace.
B. The Aſh-hole.
C. D. The Grate for the Fire.
E. The Fire-place.
F. G. H. Curvature of the inſide of the upper part of the Fire-place.
I. The Shaft or Chimney.

PLATE FOURTH.

A Cupelling Furnace.

A. The Aſh-hole.
B. B. Its ſliding Doors.
C. The Fire-place.
D. D. Its ſliding Doors.
E. F. Small apertures in the Sliders.
G. G. Holes for Bars to bear the Muffles.
H. H. H. Iron braces in the fore-part of the Furnace, which form grooves for the Doors of the Fire-place and Aſh-hole to ſlide in.
I. The upper pyramidal part of the Furnace.
K. An aperture therein for managing the Coals.
L. The opening at top.
M. The Pyramidal Cover.
N. The Chimney or end of the Shaft, on which the conical Funnel may be fitted.
O. O. O. O. Handles for moving the ſliding Doors.
P. P. Ears of the Pyramidal Cover.

N. B. The Furnaces, as repreſented in the two laſt Plates, are not in due proportion to each other. The Cupelling Furnace is much larger than it ſhould be, with reſpect to the Melting Furnace. Theſe dimenſions are here given it, only that all its parts might be more diſtinctly expreſſed, than could have been done if we had made it leſs.

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